MATERIALS HANDBOOK

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An Encyclopedia for Purchasing Agents, Engineers, Executives, and Foremen

BY

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PREFACE

Exacting demands of modern manufacturing for the correct material to meet the varying needs of each separate product, make it imperative that every executive and every workman who might be called upon to choose a material for a given job, have a fairly comprehensive idea of the raw materials in his field of activity. It is felt, therefore, that there has been need of a concise encyclopedia that would give in convenient form the chief distinguishing data on the raw materials of engineering and manufacturing.

A few years ago three or four kinds of steel, and two or three grades of brass, were sufficient to meet the needs of the average manufacturing plant. But since the advent of alloy and special steels, alloy bronzes and brasses, and the entry of entirely new materials into the workshop, a new branch of engineering has begun to be evolved. The larger manufacturing plants have recognized the need for the materials engineer who can coordinate the work of the metallurgist, physicist, and foundryman with the practical mechanical requirements of the shop engineer. The average plant, however, which has not these specialized aids, must still exercise this judgment of choice through its regular staff. It is for the purchasing department, the production executive, the engineers, and the foremen of these average plants that this book has been primarily prepared, but it has also been extended to include the more common of the engineering construction materials, and the important materials of ordnance.

Experience has shown that the industrial executive has not the time to digest the data found in the general encyclopedias, and in the specialized texts, at the time when such information is most needed by him. Moreover, in the

majority of cases, his requirements are for a quick summary of the most important technical features viewed from the consumers' standpoint only. In reference to such materials as the newer proprietary alloys, it is particularly difficult to obtain ready information. The material of this book has been gathered over a period of time through constant contact with a wide range of authorities and manufacturers, and by correspondence with the latter. Due to the vast number of references consulted, moreover, it is plainly impossible to give any adequate list of reference texts or authorities.

The term material is used in a relative sense, as it is appreciated that an article which is a finished product of one establishment may be the raw material of another. Where units of measurement are used, American equivalents of the "English" units have been largely adhered to, but it has been recognized that the general use of metric measurements and of the centigrade temperature scale in industrial laboratories makes it preferable to quote these units in many places. Conversion tables for ready reference are given in the appendix.

George S. Brady.

New York, N. Y.
October, 1928.

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Appendix I

Appendix II

MATERIALS HANDBOOK

AN ENCYCLOPEDIA FOR PURCHASING AGENTS, ENGINEERS, EXECUTIVES AND FOREMEN

Abrasives. A group of substances used in industry for surfacing and finishing metals, stone, wood, glass, and other materials. The natural abrasives include the diamond, emery, corundum, sand, crushed garnet and quartz, tripoli, and pumice. The artificial abrasives are marketed under many trade names, but are in general either silicon carbide or aluminum oxide. For general industrial grinding, artificial abrasives are generally preferred to natural abrasives because of their greater uniformity. The abrasive grains are used as a grinding powder, or are made into wheels, into "stones," or are bonded to paper and cloth. The massive material, such as sandstone, is often cut into wheels from the block. There are two general processes for making abrasive wheels: Vitrified wheels are made by running the mixture into molds, and when dry subjecting to intense heat. The silicate process consists in tamping the material into molds with a silicate of soda binder, and then baking in an oven. Synthetic resins, such as the phenol resins, are sometimes used instead of the silicate as binders, where greater strength is required than is obtained with the silicate, but less openness than with the vitrified. Rubber is also used as a binder and vulcanized where high speed is required. A binder of shellac is used on wheels for light work and for finishing. The choice of a binder is important, as it must be strong enough to hold the grains together to accomplish the desired results, and then to release them before they become too dull. The hardest abrasive is the diamond, having a hardness of 10 on the Moh scale. Garnet

is one of the softest of the "hard" abrasives, with a hardness of 6 to 7.5. The total production of natural abrasives in the United States in 1926 was 225,000 short tons, and of artificial abrasives 73,600 short tons. See also Diamond, Abrasive garnet, Corundum, Bort, Boron diamond, Silicon carbide, Aluminum oxide, Grindstones, Pulpstones, Rottonstone.

Abrasive garnet. Garnet is the general name of a group of minerals varying in color, hardness, toughness, and method of fracture, used for coating abrasive paper and cloth. Almandite is the type most employed for abrasive purposes, although andradite and rhodolite are also used. The best garnet abrasives come from the red almandite obtained in large crystals and boulders in New York State. Garnet coated paper and cloth are preferred over quartz for the woodworking industries, but certain grades of artificial aluminum oxide are now also being substituted for garnet. The grades of garnet used on papers and cloth range from No. 5, the coarsest, which is about 15 mesh, to 7/0, the finest, which is about 220 mesh. The paper used as a backing is a good quality of Kraft paper of 50 or 70 lb. weight. The usual size is 9 by 11 in. Some garnet is made into wheels by the silicate or shellac processes, but it is not possible to make vitrified wheels due to the low melting point of garnet, 1,300 deg. C. Garnet from the mines is crushed, ground, and separated and graded in settling tanks. The lighter minerals and earths of the original rock are eliminated in the settling. The production of abrasive garnet in the United States in 1927 was 6,939 short tons. See also Almandite, Andradite, and Rhodolite.

Abrasive sand. Any kind of natural sand used for abrasive and grinding purposes. Specifically, it does not include the sharp grains obtained by crushing quartz and used for "sandpaper." The chief types of abrasive sand include sandblast sand, glass-grinding sand, and stone-sawing sand. Sand for stone sawing and for marble and glass grinding is usually ungraded, with no preparation other than screening, but it must have tough, uniform grains.

Banding sand is used for the band grinding of tool handles, and for the grinding of plate glass, but is often replaced by artificial abrasives. Banding-sand grains are fine, and 95 per cent should be retained on a 150-mesh sieve, 92 per cent on a 100-mesh, 60 to 70 per cent on a 65-mesh, and 3 to 4 per cent on a 35-mesh sieve. Burnishing sand, used for polishing operations and sometimes for the finishing of valve seats, is a fine-grained, clean silica sand with rounded grains. It should pass on a 65-mesh screen, and be retained on a 100-mesh screen. See also Sand, Sandpaper, Scouring abrasive, Sandblast sand.

Abyssinian gold. A gold-shelled copper alloy employed in jewelry manufacture. It is a brass having 90 to 92 per cent of copper, and 8 to 10 per cent of zinc. The slabs are plated with gold, and then rolled out into sheets, the amount of gold on the surface being less than 1 per cent of the weight. It is also called Talmi gold. See also Brass.

Acetaldehyde. A compound used in the manufacture of synthetic resins. See Synthetic resins. It is also employed for making dyestuffs, for silvering mirrors, and for the production of paraldehyde. Acetaldehyde has the composition $CH_3{\cdot}CHO$. It is a reducing agent, and forms acetic acid on oxidation. It is a light, colorless, inflammable liquid of specific gravity 0.801, and solidifying at 21 deg. C. It is soluble in water and in alcohol. It is made by the oxidation of ethyl alcohol.

Acetic acid. An organic acid of the composition $CH_3{\cdot}COOH$, having a wide variety of industrial uses. It is used as a weak acid for etching and for soldering, in stain removers and bleaches, and as a preservative. It is also used in the manufacture of amyl acetate, which is employed as a solvent for lacquers. Acetic acid is a liquid with a pungent odor. It is also highly corrosive. The specific gravity is 1.049, and the boiling point 118 deg. C. It becomes a colorless solid below a temperature of 16.6. deg. C. In the trade, the pure solid is known as glacial acetic acid. The

acid occurs in citrous fruits, vinegar, and in the fermentation of various fruits and vegetables. It can be made by the oxidation of ethyl alcohol or acetaldehyde, but commercially it is produced as one of the products in the destructive distillation of wood.

Acetone. One of the most important of the industrial solvents, and used extensively in the manufacture of lacquers, celluloid, smokeless powders, and for dissolving acetylene for storage. Practically all of the acetylene employed for welding comes dissolved in acetone. It is also used as a raw product in the manufacture of many other chemicals. Acetone is a colorless, inflammable liquid with a mint-like odor. The composition is $CH_3 \cdot CO \cdot CH_3$, specific gravity 0.790, and boiling point 56 deg. C. It solidifies at -94 deg. C. Acetone is prepared by a special fermentation of grain, forming butyl alcohol and acetone, the latter being then distilled off. The oily residue from the distillation of acetone is called acetone oil, and is used as a denaturant for alcohol.

Acetylene. A colorless, tasteless gas of the composition $CH \cdot CH$, used widely in the mechanical industries for welding torches and for lighting purposes. It contains 92.3 per cent of carbon, and is the nearest approach to gaseous carbon. It burns brightly in the air, and when mixed with oxygen for welding torches gives a very hot flame. In a mixture of about 3 per cent acetylene to 97 per cent of air, it is sometimes used as an explosive gas. The maximum explosive effect is reached with a mixture of 7.7 per cent of the gas and 92.3 per cent of air. Acetylene has a sweet odor when pure, and is not toxic. The commercial gas, however, may contain hydrogen sulphide, which gives it a bad odor. The gas has a specific gravity of 0.92. It is soluble in water, alcohol, turpentine, or in acetone. It liquefies under a pressure of 700 lb. per sq. in. at 70 deg. F. Acetylene is easily generated by the action of water on calcium carbide. Commercially, it is compressed into cylinders, being dissolved in acetone to make it non-explosive. One volume of acetone will dissolve 25 volumes of acetylene

at atmospheric pressure, or 250 volumes at 10 atmospheres. See also Calcium carbide.

Acieral. The trade name of a light-weight alloy used for automotive engine and other parts where lightness is an important characteristic. A typical analysis of the casting alloy shows 6.4 per cent of copper, 0.4 of zinc, 0.9 of nickel, 0.1 of iron, 0.4 of silicon, and the remainder aluminum. The ultimate strength is 22,000 lb. per sq. in., elongation 2 per cent in 2 in., and density 2.84. The rolled sheet metal contains less copper, no nickel, about 1 per cent each of manganese and iron, and some magnesium. The tensile strength is about 50,000 lb. per sq. inch. The alloys are products of the Acieral Company of America.

Acrolein. The common "tear gas" of chemical warfare. It is also known as acrylic aldehyde, and has the composition $CH_2:CH{\cdot}CHO$. It is made by heating glycerol with a dehydrating agent, such as $KHSO_4$. All fats contain glycerol, and the odor of scorched fat is due largely to the acrolein formed. Acrolein is a liquid which boils at 52 deg. C., and is very volatile. The specific gravity is 0.840. It is extremely irritating to the eyes and nose. See also Poison gases, and Tear gases.

Acrolite. The trade name of a synthetic resin made by the action of phenol on glycerol in the presence of sulphuric acid. It is a product of the Diamond State Fibre Co., Bridgeport, Pa. The resin is naturally reddish-brown to deep purple in color. The latter color is when the acid has been neutralized. A hardening agent, such as para-formaldehyde, is also added. The resin is employed for molding purposes, the same as other phenol resins. It is usually mixed with wood flour or other fillers, and is molded under a pressure of 1,000 lb. per sq. in. at a temperature of 300 deg. Centigrade.

Actinic glass. The trade name of a glass which is claimed to prevent passage of the heat rays without intercepting the

light. It is marketed in sheets 61 by 140 in., either plain or wired, and is used for large windows and skylights in industrial or business buildings. It is a product of the Pennsylvania Wire Glass Company, Philadelphia.

Activated charcoal. A charcoal made from anthracite, wood pitch, coconut shells, or other organic substances, in such a manner as to drive off all traces of hydrocarbons contained in the pores of the charcoal. It is used as an absorbent material for gas masks, and for purifying acids or alcohol. It is also employed for ageing distilled alcoholic beverages by the absorption of the fusel oil. Coconut charcoal is considered the best of the activated charcoals. It is known under various trade names, such as Norit and Dorsite. Activated charcoal from anthracite is called Bachite. A charcoal is also made by saturating a coniferous wood with zinc chloride, carbonizing it at a red heat, and then washing out the salts. A requirement of these charcoals, besides great absorbing power, is that they possess mechanical strength to retain a porous structure to pass the air or liquid. See Coconut charcoal.

Adamite. The trade name of a high-carbon, chromium-nickel-iron alloy used for press dies subject to great abrasion, such as drawing or forming dies, and for rolls. It is made in various grades, all of which are cast to approximately the shape desired. The Brinell hardness ranges from 186 to 477 as cast, and the tensile strength from 35,000 to 125,000 lb. per sq. in. The softest grades can be machined and then hardened, but the hard grades are finished by grinding to size and shape. It is a product of the Mackintosh-Hemphill Company, Pittsburgh.

Admiralty metal. Also erroneously called Admiralty bronze. It is an alloy containing a minimum of 70 per cent of copper, about 1 per cent of tin, with the remainder zinc, and is therefore a tin-bearing brass. The United States Government specifications permit up to 0.06 per cent of iron, and 0.075 per cent of lead, as impurities. The alloy

is used for condenser tubes and other parts where corrosion resistance is required. It is one of the regular products of the brass mills. See also Naval brass.

Advance metal. The trade name of a white nickel-copper alloy employed as a resistance metal for electrical apparatus. It is highly resistant to corrosion. It contains approximately 45 per cent of nickel, 55 per cent of copper. The tensile strength is 62,000 lb. per sq. in., melting point 1,300 deg. C., and resistivity 294 ohms per mil-ft. at 20 deg. C. The temperature coefficient of electrical resistance is practically zero up to 400 deg. C. The weight is 0.320 lb. per cu. in. It is a product of the Driver-Harris Company, and is marketed in wire and ribbon of standard gage sizes.

Aerolite. A light aluminum alloy with specific gravity of 2.74 and having the typical composition: Aluminum 96.93 per cent, copper 1.15, zinc 0.12, iron 0.97, magnesium 0.38, and silicon 0.45 per cent. The tensile strength of cast Aerolite is 28,700 lb. per sq. in., and the elongation in 2 in. is 4 per cent. It is used in airplane and automotive construction.

Aero metal. The trade name of a light-weight alloy marketed by the Garford Engineering Company, and employed for automotive engine parts and where lightness is required. It is used in castings and in rolled sheets. A typical analysis of the cast metal shows 4.2 per cent of copper, 27.8 per cent of zinc, 0.5 of iron, 0.5 of silicon, and the remainder aluminum. The density is 3.3, and the tensile strength is about 25,000 lb. per sq. inch.

Aeron. The trade name of a German light alloy. It contains 4 per cent of copper, 1 of manganese, 1 of silicon, and the balance aluminum. It has a high tensile strength, makes sharp, sound castings, and is used for airplane and engine construction.

Agar-agar. A gelatinous substance obtained from various species of seaweed, *Algae*, growing in the Pacific and Indian Oceans. When dissolved in water it forms a

transparent jelly, and its chief industrial applications are in making gums and synthetic resins. It is also used commercially in fixing bacteria for counts, and in candies, jellies, toilet lotions, and in medicine. In the Far East it is a regular article of food. The name is also used to designate the jelly made from the plants of the genus *Gracilaria*, chiefly *Gracilaria lichenoides*, of Ceylon, and *G. spinosa*, of China. Kanten is a variety of agar-agar from the red "tengusa" seaweed, *Gelidium corneum*, of Japan. Commercial agar-agar is colorless, yellowish, or pink to black. To prepare the material the seaweeds are cleansed, pounded, bleached in the sun, and then boiled, the insoluble matter being strained out. It is marketed in strips 8 to 12 in. long and 1 to 1.5 in. wide, or in rectangular blocks of 8 in. long and 1 in. square. It is also shredded. See also Algin.

Agate. A natural mixture of crystalline and colloidal silica, but consisting mainly of the mineral chalcedony. The silicious material usually occurs in irregular banded layers of various colors. The stone is used industrially for knife edges and bearings of measuring instruments, and for pestles and mortars. It is also made into ornaments, and the finer specimens are used for gemstones. Agate was formed by the deposition from escaping vapor in eruptive rocks. It consists of about 98 per cent of silica, with metallic oxides and lime. The largest and finest agates come from Brazil and Uruguay, but the center of agate working is at Oberstein, Germany. "Moss agate" encloses filaments, mostly green, suggestive of moss. Most commercial agate is artificially stained with mineral oxides and salts, or drawn with acids to bring out strong color differences, for appearance.

Agathon steel. A general trade name for the alloy steels made by the Central Alloy Steel Corporation, Massillon, Ohio. They are produced in all standard S.A.E. analyses, and in special analyses in both open-hearth and electric steels. They are marketed in blooms, billets, bars, rods, sheets, and hot-rolled strip.

Agave. A general name for the fibers of the agave plants of Mexico and Central America. The *Agave rigida* is the source of sisal hemp, and other species of the plants furnish the tampico and istle fibres used for brushes. The plants flower once in ten years, and some species are known as century plants. The fiber is from the large leaves, which spring from the ground and attain a height of 5 to 8 ft. See Sisal hemp, Tampico, Istle.

Aich's metal. A brass containing iron. The iron content may be as high as 3 per cent, but a typical composition is 60 per cent of copper, 38.2 per cent zinc, and 1.8 per cent iron. The metal is harder than ordinary brass, has a golden-yellow color, and resists oxidation. It is intended for use where a hard and strong brass is desired, such as castings for hydraulic cylinders, or for forgings. A similar composition is also called Sterro metal. See also Forging brass.

Aircraft metals. Formerly the light aluminum and magnesium alloys were most extensively employed for airplane and dirigible construction, but alloy steels are now widely used because their superior strength permits the use of very small cross-sections to obtain the same or greater strength in the members. Chrome-vanadium steel, and chrome-molybdenum steel are the most commonly used. Stainless iron and nickel steels are also used. Duralumin and other aluminum alloys are used for some members, forged parts, and castings. Sheet Duralumin is employed in place of fabric for the sides of dirigibles. Magnesium alloys are employed for engine pistons and other bulky parts. "Y alloy" was used in the cylinder jackets and pistons of the first transatlantic airplane. Aluminum-copper is another alloy that is used for castings.

Ajax metal. The trade name of a group of white alloys used for machine and car bearings. They are made in various grades, some of which are high in copper and contain only tin, while others also contain lead. Another type

includes true babbitts, while the less expensive grades of the soft alloys are high in lead and contain antimony. The type known as Ajax standard plastic bronze contains about 64 per cent of copper, 31 per cent of lead, and 5 of tin. The type known as Ajax Bull is a low-priced babbitt containing 76 per cent of lead, 17 of antimony, and 7 of tin. It is a general utility babbitt. "Mitifine" babbitt contains no lead and a very high percentage of tin. It is used for heavy duty bearings. Each grade is intended for a particular bearing service. They are products of the Ajax Metal Company, Philadelphia.

Aladdinite. The trade name of a casein plastic employed for molding parts for electrical equipment, handles, buttons, ornaments, and many other articles. It is a product of the Aladdinite Company, Inc., Orange, N. J. It is made by the action of formaldehyde on casein. The compound or sheet can be molded into almost any shape. It is non-inflammable, and a non-conductor of electricity. It is dyed to various colors. See Casein plastics.

Albertite. A variety of natural asphalt found in Nova Scotia in rocks of the sub-carboniferous age. It yields mineral oils and coke when distilled. It is jet-black in color, and very brittle. The specific gravity is about 1.1. It is partly soluble in turpentine. See Asphalt.

Albertol resins. The trade name of a group of resins composed of natural resins combined with synthetic resins. They are made by reacting upon natural resins, such as rosin, with the reaction product of a phenol and formaldehyde, or other condensation product, and then esterifying with a polyhydric alcohol, such as glycerol. They are employed as molding compounds, and are products of the Chemische Fabriken Dr. Kurt Albert, Germany.

Alclad. The trade name of an aluminum-clad alloy which is claimed to have great corrosion-resistant properties. It is a composite metal consisting of a hard and tough aluminum alloy rolled between layers of pure

aluminum. It is a product of the Aluminum Company of America.

Alcohol. The common name for ethyl alcohol, but the name properly applies to a large group of organic substances which have important uses in industry, especially as solvents for resins, gums, rubber, and in lacquers and varnishes. A characteristic of the primary alcohols is that there is always a CH_2OH group in the molecule. The secondary alcohols have a CHOH group in the molecule, and the tertiary alcohols have the distinctive group COH. Alcohols with one OH group are called monohydroxy, and those with more than one OH group are known as polyhydroxy alcohols. Another method of classification is by the terms saturated and unsaturated. Many of the alcohols are made easiest by fermentation, while others are made from hydrocarbons. The alcohols vary in consistency. Methyl alcohol is like water, amyl alcohol is oily, and messyl alcohol is a solid. The important alcohols used in industry are ethyl, methyl, amyl, and butyl.

Alcumite. The trade name of a yellow, copper-base alloy containing aluminum, nickel, iron, and manganese, produced by the Alcumite Corporation, Dayton, Ohio, and employed for parts of chemical machinery, valves, tanks, or in other places where corrosion and acid-resistant qualities are required. It can be machined easily. Its melting point is 1,900 deg. F., and the specific gravity 8.3. The tensile strength is 75,000 lb. per sq. in. when sand cast, and 90,000 lb. per sq. in. when hot rolled. It is marketed as castings, or in sheets, rods, and wire.

Aldehyde. A group name for a number of substances which have many industrial uses, among which are the manufacture of synthetic resins for molding, and in disinfectants. Aldehydes are formed by the dehydrogenation or oxidation of alcohols, as for example formaldehyde from methyl alcohol. By oxidation again the aldehydes form corresponding acids, as formic acid. Aldehydes occur in

plant and animal tissues, and in the odorous parts of plants, giving flavor to such things as the lemon, rose, and orris. See Formaldehyde, Acetaldehyde, Furfural.

Alder. The wood of the tree *Alnus glutinosa*, which belongs to the beech family and is widely distributed in Europe and Asia. The wood is tough and resilient, and is used extensively as a ply-wood. It is also employed for cabinet work, toy making, and other uses. It is of a reddish-white color and has a smooth, fine grain. The weight is about 35 lb. per cu. ft. Red alder is from the *Alnus rubia*, a large tree of the United States and Canada, and is used for wooden ware, furniture, and inside construction work. The color of the wood is light brown, and the weight is about 30 lb. per cu. ft. Formosan alder is from the tree *Alnus maritima*, native to Formosa. The wood is of a light yellow color streaked with reddish lines, and it has a fine texture. The weight is 33 lb. per cu. ft. It also has a great variety of uses.

Aldrey. The trade name of a light aluminum alloy used in Germany for automotive engine construction. It is composed largely of aluminum with some silicon and a smaller amount of magnesium. The silicon increases the fluidity, and makes possible sharp and firm castings.

Algin. Also called alginic acid. A substance obtained from sea weeds as a by-product in the manufacture of iodine and potash, and used in the manufacture of molding compounds. It is a colorless mass resembling gelatine, and has the composition $C_{21}H_{27}O_{20}$. When dried it becomes hard and horny. Algin is only slightly soluble in water, and is insoluble in alcohol. When dissolved in sodium carbonate solution and partially neutralized with hydrochloric acid, the sodium alginate forms colorless sheets, tough and flexible, but soluble in water. After application to cloth or other materials which it is desired to cover, the sodium alginate is again treated with acids to make it insoluble and waterproof. See also Agar-agar.

Alkali. A caustic hydroxide characterized by its ability to form soluble soaps with fatty acids. The common alkalis are sodium hydroxide and potassium hydroxide, and these are the ones that enter into soluble oils and cutting compounds, and in cleaning materials and soaps. "Fixed alkalies" are the carbonates of the alkaline metals. Ammonia is called a volatile alkali. The hydroxides of calcium, strontium, and barium show a strong alkaline reaction in solution, and are called the earth metals. All of the alkalies have a brackish taste and a soapy feel. Most vegetable and animal substances are corroded by alkalies, from which the latter derive the names "caustic soda," and "caustic potash."

Alligator leather. A light, tough leather with plate-like scales on the outside, employed as an ornamental covering leather. It is made from the skins of large saurians, or lizards of the natural order *Crocodilia.* The species *Alligator mississippiensis* inhabits the swamps and bayous of Florida and Louisiana. The alligator abounds in muddy tropical streams. The mature animal is usually 6 to 7 ft. long, and reaches this length in 5 or 6 years. Alligator leather is much imitated with embossed split sheepskins.

Alloy. A solid solution of two or more metals. Chemically, an alloy is a solution that is entirely homogeneous, but the commercial use of the term also includes mixtures of metals that do not dissolve in each other. Aluminum and lead, for example, are likely to form droplets or layers of one of the metals on cooling. The commercial utility of alloys arises from the fact that the pure metals are often too soft, weak, or rare for use alone. Thus, copper, a soft metal, when alloyed with the brittle metal zinc, forms a strong, hard alloy, brass, that has many commercial uses. The number of possible alloys is infinite. They are made by fusion of the metals, and are distinct from products such as Widia metal, which is made by the diffusion of particles in close contact. Some alloys contain chemical crystals of the metals. Thus, bronze contains a percentage of copper-

tin crystals. The melting point is always lowered by the addition of one metal to another in an alloy. The most common general groups of alloys are: brass, bronze, babbitt, alloy steels, German silver, aluminum alloy.

Alloy steel. The name given to a class of steels owing their distinctive properties to elements other than carbon. Some of the alloy steels also contain a high percentage of carbon to give them the hardening characteristics of tool steels. Alloy steels usually take the name of the element or elements having the greatest influence on the characteristics of the alloy, regardless of the percentage of the element contained in the steel. These alloys include vanadium steel, nickel steel, chrome-vanadium steel, nickel-chromium steel, and silicon steel. High-speed steels are generally placed in a class by themselves, and are not considered as alloy steels. See High-speed steel. The alloy steels are used in automotive and machinery parts where great strength and toughness are required, and where the cost is warranted. Special alloy steels are also much used in construction work. Each alloy steel has its own peculiar properties. The production of alloy steel ingots in the United States in the year 1927 was 2,121,000 gross tons. See also Steel.

Almandite. One of the six varieties of the mineral garnet, used extensively as a coating for abrasive paper and cloth. New York State is the leading producer. The composition of pure almandite is $Fe_3Al_2(SiO_4)_3$. It forms crystals of a fine deep-red color, with a hardness of about 7.5 on the Moh scale. Precious garnets, used as gemstones, are choice specimens of almandite, found mostly in India, Brazil, Australia, Alaska, and in the Alps. See Abrasive garnet.

Almo steel. The trade name of a chrome-molybdenum steel made by the Crucible Steel Company of America. The chief characteristic of the steel is great toughness, and it is recommended for airplane, automotive, and ordnance work. The hardening and tempering ranges are also wide, making heat-treatment simple. There are three grades,

each of which are produced in three different carbon contents suitable for forgings, gears and springs. Grade 1 has an ultimate strength of 167,000 lb. per sq. in., Brinell hardness of 340, and elongation of 17.5 per cent in 2 in. Grade 3, the lowest, has a tensile strength of 134,000 lb. per sq. in., Brinell hardness of 277, and elongation of 15 per cent.

Alobrant. The trade name of an artificial corundum, or aluminium oxide, produced by the Brantford Grinding Wheel Company, Inc., Brantford, Ontario, and employed as an abrasive. See Aluminum oxide.

Alowalt. An artificial aluminum oxide used as an abrasive. It is a product of the Waltham Grinding Wheel Company, Waltham, Mass. See Aluminum oxide.

Aloxite. The trade name of an artificial abrasive made by the Carborundum Company, Niagara Falls. It is an aluminum oxide. Aloxite AA is a purer grade containing less than 1 per cent of impurities, and used for toolroom grinding. Aloxite K-5 is a grade used for abrasive paper to replace garnet paper. See Aluminum oxide.

Alpaca. The trade name of a white alloy used as a base metal of tableware. It contains about 65 per cent of copper, 20 of zinc, 13 of nickel, and 2 per cent of silver. Its color is very similar to that of silver. It is usually plated with silver, takes a fine polish, and is resistant to corrosion. Alpaca is widely imitated, but some of these alloys contain no silver, and are of inferior quality for the best "silverware."

Alpax. An aluminum-silicon alloy invented in England by Aladar Pacz. It contains 87 per cent of aluminum and 13 per cent of silicon. It is fine-grained and ductile, but is difficult to machine as the metal clings to the tool. The tensile strength is as high as 32,000 lb. per sq. in., and the elongation 5 to 10 per cent in 2 in. The Brinell hardness is 52. It is somewhat lighter than aluminum.

Alsifer. A trade name for a silicon-aluminum-iron allo employed as a deoxidizing agent in making iron and stee alloys. It increases the density of the steel. It is a produc of the Vanadium Corporation of America. The following i a close analysis: Aluminum 20 per cent; silicon 40 per cent and iron 40 per cent. The aluminum and silicon are i the form of an aluminum silicate, which gives a slag that i eliminated during the teeming of the steel, and the allo does not remain in the final steel. Alsifer contains n carbon, and is free from carbide of aluminum. It i marketed in ¼-screen, ¾-screen, and in "egg size." Fron 1¼ to 3¾ lb. is used per net ton of steel.

Alterite. The trade name of a corrosion-resistant allo containing copper, nickel, and iron in varying proportion depending on the requirements. The ranges are 10 to 4 per cent of nickel, 30 to 40 per cent of copper, 5 to 10 pe cent of iron, and varying percentages of zinc. It is als resistant to many acids and salts, and is used for hardware valves, and plumbing fixtures. The alloy casts easily, an is also rolled and drawn. It is nickel-white in colo

Alulion. An artificial corundum, or aluminum oxide used as an abrasive. It is a product of the Lion Grindin Wheels, Ltd., Brockville, Ontario. See Aluminum oxide

Alum. A compound used extensively as an astringent, i pigments, and for purifying water. It is a colorless t white crystalline substance of the chemical compositio $K_2SO_4 \cdot Al_2O_3(SO_3)_3 \cdot 24H_2O$, occurring as the miner kalinite, and also in combination in the mineral alunite It has a sweetish taste, and is very astringent. It is solubl in water, crystallizing out in octagonal or cubical crystal and is employed in this way for purifying water as th precipitate takes with it the organic impurities. Alum has specific gravity of 1.757. It melts in its water of crysta lization at 93 deg. C., and when heated to redness is co verted into "burnt alum," a porous, friable material whic dissolves in water slowly. Soda alum, in which the pota

sium is replaced by sodium, occurs naturally in the South American Andes as the mineral mendozite. It is more soluble than alum, but is more difficult to purify.

Alumalun. The trade name for an "anti-slip" metal made of aluminum alloy with carborundum grains cast in the metal. It is used for floor plates, stair treads, car steps, and door saddles. It is a product of the American Abrasive Metals Company.

Alumel. The trade name of a heat-resistant alloy used for electrical resistance wires and thermocouples. It contains 94 per cent of nickel, 2.5 per cent of manganese, 0.5 per cent of iron, and small amounts of other elements. It withstands temperatures continuously up to 1,250 deg. C. The melting point is about 1,400 deg. C. It is furnished in wire, and is a product of the Hoskins Manufacturing Company, Detroit.

Alumina. The only known oxide of aluminum, Al_2O_3. In crystalline form it is used commercially as an abrasive, and for gemstones. See Aluminum oxide and Corundum. It is widely distributed in nature, occurring as the mineral corundum, in bauxite, and in combination with silica in many other minerals. Pure alumina is a white, amorphous powder when prepared by precipitating aluminum hydrate from a solution of alum with ammonium carbonate, and calcining. The melting point is 3,650 deg. F. Alumina is an important constituent of the clays for making porcelain, bricks, and pottery, and for refractories. It is also used as a mordant in dyeing.

Aluminite. The trade name of an artificial corundum employed as an abrasive. It is a product of the Macklin Company, Jackson, Mich. See Aluminum oxide.

Aluminoid. An artificial aluminum oxide used as an abrasive. It is a product of the General Grinding Wheel Corporation, Philadelphia. See Aluminum oxide.

Aluminox. An artificial corundum used as an abrasive. It is a product of the American Emery Wheel Works, Providence. See Aluminum oxide.

Aluminum. A bluish-white metal, symbol Al, obtained chiefly from the mineral bauxite by roasting and reducing. It is the most widely distributed of all the elements next to oxygen and silicon, 7.3 per cent of the earth's crust being composed of aluminum. The metal has a specific gravity of 2.7, melting point of 1,218 deg. F., and boiling point of 3,272 deg. F. Its ultimate tensile strength, cast, is 12,900 lb. per sq. in., with an elongation of 29 per cent in 2 in. The chief impurities in commercial aluminum are iron and silicon, but Grade A aluminum averages 99.3 per cent pure. Aluminum ingot is usually specified 99 per cent pure. Aluminum is resistant to corrosion, and only surface-oxidizes in the air, but it is attacked by alkalies and hydrochloric acid. It is employed as a light metal for automotive and airplane construction, especially in alloys with magnesium, copper, and other metals. It is marketed in the form of sheets, tubes, and rods, generally containing copper. See Aluminum alloy. Aluminum sheet, containing at least 99 per cent of aluminum, has a tensile strength of 12,000 lb. per sq. in., and an elongation of 15 to 30 per cent. Aluminum is also used as a foil in place of tinfoil. In powder form it is used in paints and fireworks. With iron oxide it is used for "Thermit" welding. The world production of aluminum in 1926 was 235,000 tons.

Aluminum alloy. The general name in industry for an alloy of aluminum and copper, which is known in the finished article as "aluminum." In general it contains 92 per cent of aluminum and 8 per cent of copper, but the aluminum content may be as low as 88 per cent, with as high as 1.5 per cent of iron, and small quantities of zinc, silicon, and other elements. Most of the aluminum alloys can be hardened by "ageing," which consists in quenching from a temperature of 950 deg. F. and allowing to stand for several days. A casting alloy used by the General Motors Corpora-

tion has a minimum ultimate strength of 18,000 lb. per sq. in. The aluminum alloys of this company are made by adding "hardener" ingots to aluminum. This hardener has a composition of 50 per cent aluminum and 50 per cent copper, with a tolerance of plus or minus 2 per cent of either, and may also contain up to 1 per cent of iron, 1 per cent of zinc, and 0.50 per cent of silicon. An aluminum alloy used by the Westinghouse Electric & Manufacturing Company contains 7 to 8.5 per cent of copper, 1.5 of silicon, and 1.2 of iron. Its tensile strength is 18,000 lb. per sq. in. Alloys of aluminum are marketed under a very wide variety of trade names such as Aeron, Alganite, Aluminite, Fontane Metal, Wolframium, Zimalium, and many others. Commercial aluminum alloy rod, wire, and tubing generally contain more aluminum, about 94 per cent, and are of very uniform quality, with a tensile strength of about 40,000 lb. per sq. in. when hard rolled. The specifications of the Federal Specifications Board for first-grade aluminum alloy rods, bars, and shapes, call for 92 per cent minimum of aluminum, 3.5 to 4.5 of copper, 0.2 to 0.75 of magnesium, and 0.4 to 1.0 of manganese. This alloy has a tensile strength of 55,000 lb. per sq. in. See also Duralumin.

Aluminum-beryllium alloys. Various patents have been obtained on alloys of beryllium with aluminum. Only small quantities of beryllium are used, generally under 1 per cent. This metal has the effect of hardening the alloy, and also improving its machining qualities. An alloy containing 0.30 per cent of beryllium was shown to have a tensile strength of 11,100 lb. per sq. in., and an elongation of 34.5 per cent, while one containing 2.06 per cent of beryllium had a tensile strength of 13,230 lb. per sq. in. and an elongation of 30.5 per cent. A 23-per cent beryllium alloy had a tensile strength of 38,000 lb. per sq. in., and an elongation of 4 per cent in 2 in. Aluminum-beryllium castings show a decided hardening by ageing, amounting to as much as 60 per cent increase in hardness. The alloys are made by melting the aluminum at a temperature of 1,000

to 1,200 deg. C., sprinkling barium chloride on the surface, dropping in the beryllium, and stirring. German Duralumin and Lautal have been made containing 1 to 1.8 per cent of beryllium, and giving tensile strengths above 50,000 lb. per sq. in. See also Beryllium.

Aluminum brass. A casting brass containing a small amount of aluminum, which acts as a flux to eliminate impurities and give the alloy greater fluidity. The excess of aluminum remaining in the alloy is usually not more than 0.50 per cent. The addition of the aluminum permits the use of higher percentages of lead up to about 5 per cent, making the castings easier to machine. Aluminum brass is employed for making intricate castings.

Aluminum bronze. The name of a class of copper-rich aluminum alloys containing from 2 to 15 per cent of aluminum. The commercial alloys usually contain from 5 to 11 per cent. A common alloy contains 95 per cent of copper and 5 of aluminum. It has a tensile strength of 65,000 lb. per sq. in., and elongation of 55 per cent. Above 12 per cent of aluminum the alloys are very brittle. The iron content may be as high as 3 per cent, and the nickel as high as 4 per cent. An alloy of 88 per cent copper, 7 of aluminum, 3 of iron, and 2 of manganese gave a tensile strength of 74,000 lb. per sq. in., and an elongation of 40 per cent in 2 in. A 10-per cent aluminum bronze hardened at 1,650 deg. F., and then drawn at 570 deg. F. gave a tensile strength of 108,000 lb. per sq. in. An alloy containing 10 per cent of aluminum, and 7 of nickel, has a tensile strength of 84,000 lb. per sq. in., is very dense, and is used for hydraulic cylinders. A small amount of titanium has also been used in aluminum bronze for high-strength gears. The percentage of other metals in the alloys never exceeds 25 per cent of the combined content of copper and aluminum. The alloys are very resistant to corrosion. They can be cast or forged, and those with less than 7 per cent of aluminum can be cold-worked. They machine with difficulty because of the free aluminum oxide always present. Th

melting point ranges from 1,890 to 1,920 deg. F. They can be hardened and drawn much like steel. Aluminum bronzes are employed for many mechanical parts. They are especially suitable for bearings because of the hard crystals imbedded in a soft backing. Aluminum bronzes are often sold under various trade names. See McGill metal, Turbiston's bronze.

Aluminum carbide. A grayish, massive substance of the composition Al_4C_3, of specific gravity 2.36, formed by heating aluminum oxide and coke in the electric furnace. It decomposes in water, liberating methane, and is employed for the generation of methane gas, which is used for carbonizing steels.

Aluminum foil. Very thin sheet aluminum employed for wrapping various articles in place of the more expensive tin foil. It does not effectively replace lead and low-priced composition foils for wrapping non-edible articles, and does not possess the high silvery luster of tin foil demanded for the best confectionery, but it has numerous intermediate uses. Aluminum foil comes in 34 thicknesses from 0.006 mm. (0.00024 in.) to 0.200 mm. (0.00787 in.), the thinnest having 43,300 square inches per pound, and the thickest 1,169 square inches per pound. It is packed interleaved with 10-lb. tissue paper, or with 16-, 20-, and 30-lb. waxed paper. The waxed paper is used with the foil in wrapping, but is not attached to foil of a thickness greater than 0.00065 inch.

Aluminum-manganese alloy. An aluminum alloy containing manganese. The addition of manganese to aluminum is claimed to increase the resistance to corrosion, and also to reduce the tendency to electrolytic corrosion when employed for pipes and tubes. An alloy of this type, known as 3-S, is produced by the Aluminum Company of America, and contains 1.25 per cent of manganese. It has a tensile strength of 30,000 lb. per sq. in. when hard-rolled, and 15,000 lb. per sq. in. when soft. In the latter state it has an elongation of 25 per cent in 2 in. The addi-

tion of 1 to 2 per cent of copper to an aluminum-manganese alloy makes it forge easily, and increases the tensile strength.

Aluminum oxide. An artificial corundum, Al_2O_3, made by fusing bauxite in a special arc-type electric furnace. When pure it is a white powder, or it forms in colorless crystals. The specific gravity is 3.75, and melting point about 3,720 deg. F. The crystalline variety is employed as an abrasive, and is usually marketed under trade names, such as Alundum, Aloxite, Hytens. It is also employed in making refractory linings and crucibles, with 10 to 25 per cent of refractory clay as a binder. For abrasive purposes it is used in various grades depending upon the purity. When hard, sharp crystals are required the highest grades are employed, but it is usually preferred with some impurities for average use. The crystals are minute, and the larger grain sizes are made up of many crystals, which is a distinctive point from silicon carbide. For industrial abrasive uses artificial aluminum oxide is usually preferred to corundum because of its greater uniformity. The recommended standard grain sizes are from No. 3½, which is 20-mesh, to No. 5/0, which is 180-mesh, but finer grain sizes are used, to 320-mesh. For abrasive paper the grains are glued to one side of a good grade of 40-, 70-, or 90-lb. Kraft paper. The usual size of sheet is 9 by 11 inches.

Aluminum paint. A class of finishing material made of fine flakes of aluminum suspended in a suitable vehicle. Powdered or granular aluminum is not suitable for aluminum paint. The vehicle may be boiled linseed oil, oil varnishes, gloss oils, or pyroxylin lacquer. Aluminum paint made with linseed oil gives a softer surface when dry than varnish-base paints. From 20 to 25 per cent by weight of flake is usually recommended. Aluminum paint reflects 70 per cent of the light energy that falls on it, and is therefore used for painting tanks and structures which must be kept cool. It also radiates heat poorly, and is valuable for that reason for painting ovens and stacks. It is also employed for protecting metal against corrosion.

Aluminum palmitate. A yellowish, massive salt, or a fine white powder of the composition $Al(C_{15}H_{42}O_4)_3$, made by heating a solution of aluminum hydroxide and palmitic acid. It is soluble in oils and benzol, but insoluble in water. Aluminum palmitate is used in waterproofing cloth, and in paints as a drier. Another drier of the same class is Aluminum resinate, $Al(C_{14}H_{63}O_5)_3$, a brown mass made by heating resin and aluminum hydroxide. Aluminum oleate, $Al(C_{18}H_{33}O_2)_3$ is the white salt of oleic acid used also as a drier in paints.

Aluminum-silicon alloys. Light alloys containing up to about 13 per cent of silicon, and the balance aluminum. They cast very well even in thin sections, and are free from hot-shortness and shrinkage cracks. They are resistant to corrosion, are ductile, and are lighter in weight than pure aluminum. The 5 per cent alloy has a tensile strength when quenched and aged of about 20,000 lb. per sq. in., and an elongation of 17 per cent in 2 in., while the 13 per cent alloy has a tensile strength up to 32,000 lb. per sq. in., and an elongation up to 10 per cent. Aluminum-silicon alloys are marketed under various trade names such as Alpax, Alumac. They are used for automotive engine parts.

Aluminum stearate. A yellowish salt of stearic acid with the composition $Al(C_{18}H_{35}O_2)_3$. It is not soluble in water, and has the property of not being easily wetted by water. It is used to impregnate fabrics to make them waterproof, and as a drier for paints.

Alundum. The trade name of an artificial aluminum oxide made in the electric furnace, and used as an abrasive. The specific gravity is 3.91, and melting point 2,050 deg. C. It is a product of the Norton Company, Worcester, Mass. See Aluminum oxide, and Abrasives.

Amalgam. A combination of a metal with mercury. Amalgams are made with gold, silver, copper, tin, lead, and

cadmium. They are used for filling where it is not possible to use high temperatures. A characteristic of amalgams is that when slightly heated they are soft and easily workable, but when set become very hard. A native silver amalgam found in Northern Europe and in South America contains from 26 to 95 per cent of silver. Native gold amalgams are found in California and Colombia, and contain about 40 per cent of gold. Native amalgams are chemical combinations of the two metals, while some of the commercial artificial amalgams are alloys, and others are compounds. Sodium amalgam is made in grades containing 2 to 10 per cent of sodium. It is a silver-white mass, which decomposes water, and is used for producing hydrogen.

Amatol. A high-explosive used as a bursting charge in shells. It is a mixture of ammonium nitrate and TNT in the proportions of 50-50 for shells from 75 mm. to 4.7 in., and 80–20 for shells from 4.7 to 9.2 in. Amatol is hygroscopic and insensible to blows and friction, but can be detonated by severe impact. It does not form dangerous compounds with metals other than copper and tin. Amatol is made by melting the TNT and placing in a jacketed mixer with the ammonium nitrate for a time sufficiently long to insure each grain of nitrate being thoroughly coated with the TNT. The 50–50 mixture is fluid, and the 80–20 is plastic like moist brown sugar.

Amber. A fossil resin found buried in certain parts of northern Europe near the Baltic Sea. It is employed for making amber varnishes, and for ornaments. It is thought to have come from a coniferous tree, *Pinus succinifer*, now extinct. It is hard, brittle and tasteless, and dissolves in acids. It is sometimes transparent, but usually semi-transparent or opaque with a glossy surface. The colors are chiefly yellow or orange. It takes a good polish. When rubbed it becomes electrically charged. The density is 1.065 to 1.070. Amber contains succinic acid in a complex form. The world supply of amber is very limited. Synthetic amber is a phenol-formaldehyde resin, made more

pliant and transparent by adding amyl alcohol, camphor oil, or glycerol.

Amberoid. A name given to the small scrap pieces of amber when made into a solid cake by heating and compressing. Pieces of copal and other resins may also be mixed with the amber in making amberoid. It has the same uses as amber.

Ambrac. A corrosion-resistant alloy containing 75 per cent of copper, 20 per cent of nickel, and 5 per cent of zinc. When hard-drawn into fine wire it has a tensile strength of 145,000 lb. per sq. in. It is used for screens, and for parts of machinery where resistance to corrosion is important. It is a product of the American Brass Company.

Amerith. The trade name of a pyroxylin plastic molding material marketed in sheets, rods, and tubes, and used for making mechanical parts, novelties, non-shatterable glass, automobile curtains, and a great variety of other articles. It is a product of the Celluloid Corporation, Newark, N. J. See Pyroxylin plastics.

Aminoform. A name sometimes applied to the reaction product of ammonia and formaldehyde, used in the manufacture of synthetic resins. See Hexamine.

Amlo oil. The trade name of an "aviation motor lubricating oil," the product of the Texas Pacific Coal and Oil Company. It is refined from high-grade paraffin-base crude oil, and is entirely wax free. It can be used below freezing temperatures, and is suitable for aviation use at high altitudes.

Ammonia. A gaseous compound of nitrogen and hydrogen, of the formula NH_3. It is also called volatile alkali, or by the old name "spirits of hartshorn." The chief source of ammonia is as a by-product in the distillation of coal in gas works, but it is also produced by the direct union of nitrogen and hydrogen in the presence of a catalyst.

It is readily absorbed by water, which takes up 670 times its own volume of the gas, forming the liquid commonly called ammonia. The powerful absorption power of ammonia is made use of in freezing machines. Ammonia is also used as a deodorant, as a solvent, and in medicine as a stimulant. The smelling salts of commerce is carbonate of ammonia. Anhydrous ammonia is the purified ammonia gas liquidified by pressure and put up in steel cylinders.

Ammoniac. A gum resin from the stems of the *Dorema ammoniacum*, a plant native to Persia and northern India. It has a peculiar, fetid odor, and an acrid taste. It is used industrially as an ingredient of porcelain cements. Oil of ammoniac is a yellow liquid distilled from the gum. It has a specific gravity of 0.885 to 0.891, and boils at about 275 deg. C. It is soluble in alcohol, ether, and in benzol.

Ammonium chloride. Commonly known as sal ammoniac, and used as a soldering flux. A whitish, crystalline substance of the composition NH_4Cl, formed by the reaction of hydrochloric acid and ammonia. It is also used in electric batteries, textile printing, and for making other ammonium compounds. The specific gravity is 1.52. When heated it volatizes without melting.

Ammonium hydroxide. Also known as ammonium hydrate, and aqua ammonia. A colorless liquid, of the composition NH_4OH, with a boiling point of 38 deg. C., and soluble in water. It is obtained by distilling gas liquor, or it can be made synthetically by the union of hydrogen and nitrogen with a catalyst. It is used for the saponification of fats and oils, and as a bleaching agent.

Ammonium nitrate. A colorless, crystalline substance of the composition NH_4NO_3, highly explosive, and used in explosives. It is made by the action of nitric acid on ammonium hydroxide. The specific gravity is 1.725, melting point about 160 deg. C., and decomposing point 210 deg. C. It is soluble in water, alcohol, and in alkalies.

Ammonium perchlorate. A white, crystalline substance of the composition NH_4ClO_4, made by the action of perchloric acid on ammonium hydroxide. The specific gravity is 1.95. It is soluble in water, and decomposes on heating. It is highly explosive, and is employed in explosives.

Ammonium persulphate. A white, crystalline substance of the composition $(NH_4)_2S_2O_8$, produced by the electrolysis of a solution of ammonium sulphate. It is used in electroplating, and also in photography. It is soluble in water, and decomposes without melting when heated.

Ampco metal. The trade name of an "aluminum bronze," containing 80 to 88 per cent of copper, 7 to 10 per cent of aluminum, and 5 to 10 per cent of iron. It is a product of the American Metal Products Company, and is marketed in 10 grades. The weight is about 3 per cent less than that of steel. It has a golden-yellow color, and takes a fine polish. It is used for bearings, packings, gears, and machine parts. The hardest grades are difficult to machine. It can be forged, and the softer grades can be hardened by quenching in water from a temperature of 1,650 deg. F. The melting point is 1,850 to 1,950 deg. F. The tensile strength varies from 50,000 to 100,000 lb. per sq. inch.

Amphibole. The name of a group of minerals of which the fibrous varieties, actinolite and tremolite, form some of the asbestos of commerce, and nephrite is the jade of the Orient. The amphiboles are chiefly meta-silicates of calcium and magnesium with iron replacing part of the magnesium. They occur coarse to fine granular, in crystals or compact, and sometimes in silky fibers. The specific gravity is 3 to 3.3, and the hardness is 5 to 6. The color varies from white to green and black. The mineral is very widely distributed. See Asbestos.

Amsco steel. The trade name of a steel containing a high percentage of manganese. It is used for casting machine parts that are subject to severe abrasive condi-

tions. It will also withstand hard blows and shocks, and is employed for making such parts as steam shovel teeth. It is a product of the American Manganese Steel Company, Chicago. See Manganese steel.

Amyl acetate. Commonly known as banana oil because of the odor of bananas. It is a colorless liquid of the composition $CH_3COOC_5H_{11}$, and is an ester formed from the inter-action of amyl alcohol and acetic acid. Its specific gravity is 0.876, and the boiling point is 139 deg. C. It is insoluble in water, but dissolves in all proportions in alcohol and ether. It readily dissolves resins, tannins, and camphor, and is employed for varnishes, lacquers, and some paints. It is largely employed as a solvent for pyroxylin finishes.

Amyl alcohol. A colorless liquid of the composition $C_2H_5{\cdot}CH_3{\cdot}CH{\cdot}CH_2{\cdot}OH$, specific gravity 0.8169, and boiling point 128 deg. C. It is made by fractional distillation of fusel oil, and is used extensively for producing amyl acetate, or directly as a solvent for lacquers. Tertiary amyl alcohol, $(CH_3)_3{\cdot}C(OH)CH_2$, has a specific gravity of 0.8144, melting point of -12 deg. C., and boiling point of 102 deg. C. Normal amyl alcohol, $CH_3(CH_2)_4OH$, has a specific gravity of 0.817, and boiling point of 138 deg. C. See also Fusel oil.

Andradite. One of the varieties of common garnet, named after the Portuguese mineralogist d'Andrada. It is employed for coating abrasive paper and cloth. Its composition is $Ca_3Fe_2(SiO_4)_3$. The color is yellow, green, or brown to black, and the hardness is 6.5. A green andradite known as demantoid comes from the Ural Mountains, and makes the fine gemstones called Uralian emeralds. See Abrasive garnet.

Angico. The wood of the tree, *Piptadenia rigida*, of Brazil. It is known also under various other names, as queen-wood and angico vermelho. The wood is extremely hard, with a dense, close grain. The color is reddish-brown, and the weight is 71 lb. per cu. ft. Logs are obtainable 10 in. in diameter. Angico is employed in construction

where a hard, heavy wood is desired. It is also used in cabinet making and ornamental work.

Anglesite. A secondary ore of the metal lead. It is formed by the oxidation of galena, and is found usually in the oxidized portions of lead veins associated with galena and other minerals. It is a common mineral occurring in many localities. Anglesite is a lead sulphate of the composition $PbSO_4$, containing 68 per cent of lead. It occurs in crystals, massive, or granular. Its hardness is 2.75, and specific gravity is 6.12 to 6.39. The color may be white, pale shades of yellow or blue, or it may be colorless.

Aniline. Also known as amino-benzene. A colorless, oily liquid employed extensively in the preparation of dyestuffs. From it is also produced drugs, perfumes, explosives, flavoring substances, and other materials. It is found in coal tar and bone oil, or is made by the reduction of nitrobenzene by treating it with a mixture of water and iron filings in the presence of hydrochloric acid. The composition is $C_6H_5 \cdot NH_2$. Pure aniline boils at 182 deg. C., and solidifies at -7 deg. C. The specific gravity is 1.026. It is soluble in all proportions in alcohol, ether, and benzene. Aniline is a poison when taken internally or inhaled. It has a powerful effect on the nervous system, and causes decomposition of the blood. Aniline turns brown in the air, and is finally oxidized into a resin.

Animi gum. A gum-resin obtained from the stem of the plant *Hymenoea courbarii*, of Zanzibar and East Africa, and employed in varnishes. It is distinguished from copal by the ease of solubility in alcohol. The specific gravity is 1.062 to 1.068, and melting point is about 245 deg. Centigrade.

Anthracite. Also called hard coal. A variety of mineral coal found in South Wales, France, Saxony, but in greatest abundance in the United States in Pennsylvania. It is distinguished by its semi-metallic luster, high carbon content, and high specific gravity. The specific gravity of

clean anthracite is about 1.70. The carbon content may be as high as 95 per cent, but the usual fixed carbon content is from 78 to 84 per cent. Anthracite burns without smoke or smell, and thus has a great advantage over bituminous coals for heating furnaces. It is much more costly, however. Anthracite is graded chiefly by its size, varying from three sizes of very fine grains called "silt," "rice," and "buckwheat," to the largest size of "furnace" coal. It is also graded as anthracite and semi-anthracite depending upon the ratio of fixed carbon to volatile matter. When this ratio is 10 to 1 it is anthracite. See also Coal.

Antimonial lead. An alloy composed of from 3 to 10 per cent of antimony with the balance lead. It is used for storage battery plates, bullets, type metal, and tank linings. The antimony hardens the lead. The usual alloy contains from 4 to 6 per cent of antimony, and has about twice the tensile strength of pure lead.

Antimony. A bluish-white metal, chemical symbol Sb, having a crystalline, scale-like structure. It is very brittle, and easily reduced to powder. It is neither malleable nor ductile, and is only used in alloys, especially with lead and tin. The specific gravity is 6.62, and melting point 824 deg. F. It burns with a bluish-white light when heated to redness in the air. Antimony imparts hardness and a smooth surface to soft-metal alloys, and alloys containing antimony expand on cooling, thus reproducing the fine details of the mold. When alloyed with copper it makes a crystalline alloy valued for machine bearings. It is also used in the manufacture of wallpaper, fabrics, paper, and paints. About 85 per cent of the world's supply of antimony, which averages 18,000 tons annually, is produced in Hunan Province, China. The chief antimony ore is stibnite, from which it is obtained by roasting out the sulphur and reducing with carbon. It is usually sold in small flat cakes, either circular or rectangular. The best grades of commercial antimony are 99.6 per cent pure. Impurities are lead, sulphur, copper, tin, and arsenic.

Antimony red. The trisulphide of antimony of the composition Sb_2S_3, precipitated from solutions of antimony salts in orange-red crystals, and used as a paint pigment. The specific gravity is 4.56, and melting point 546 deg. C. The mineral stibnite is an impure form of antimony trisulphide. One of the chief uses of the pigment is in the coloring of red rubber. It is also used in the manufacture of safety matches.

Antimony sulphate. A white, explosive powder of the composition $Sb_2(SO_4)_3$, formed by the action of sulphuric acid on antimony trioxide. The specific gravity is 4.89. It decomposes in water. It is used in making explosives.

Antler. The bony, deciduous horns of animals of the deer family, and used commercially for making handles for knives, umbrellas, and other articles. Antlers are true outgrowths of bone, and are not simply hardenings of outer tissue as are the horns of other animals. They are of various shapes and sizes, and are usually found only on the male during the mating season, though both sexes of reindeer and American caribou possess them. Unlike horn, antlers are solid. They grow in from 3 to 4 months, and are shed annually. Antler for knife handles is imitated by machine carving of ordinary bone.

Apitong. The wood of the tree *Dipterocarpus grandiflorus*, native to the Malay Peninsula, Borneo, and the Philippines. The wood is of a reddish-brown color, and has a weight of 44 lb. per cu. ft. Many other varieties of trees of the family *Dipterocarpus* yield woods which are included under the name of apitong. A total of 4,200,000 bd. ft. of apitong was exported from the Philippine Islands in 1927 to the United States and Europe. The wood is employed for veneering and for cabinet work.

Aqua fortis. The old name for dilute nitric acid, still commonly used in the trade. The grade of solution usually known as aqua fortis contains about 65 per cent of nitric acid, measuring 42 deg. Be. See Nitric acid.

Aqua regia. The common name given to a mixture of 3 parts of hydrochloric acid and 1 part of nitric acid. It is a yellow, volatile liquid with suffocating fumes. Aqua regia is employed chiefly for dissolving or testing gold, platinum, and palladium.

Arbor vitae. A name for the western and Canadian red cedar, *Thuya occidentalis.* The name is also applied to other cedars. The wood is brownish in color, and has a close, even grain. It is very soft, but is durable when exposed to the weather. It is used for telegraph poles, posts, and shingles. The weight is about 29 lb. per cu. foot. Although known commercially under the name of cedar, the tree is not a true cedar. See also Western white cedar.

Arenga fiber. A stiff, strong fiber used for brushes. It is obtained from the leaves of the palm tree *Arenga saccharifera* of the East Indies. The finest qualities of the fiber resemble horsehair.

Argentine metal. The name of a "silvery" alloy employed for making statuettes and other small ornaments. A typical alloy contains 85.5 per cent of tin and 14.5 per cent of antimony. The latter metal hardens the alloy, and also makes clean-cut castings due to its property of expanding on cooling. A similar alloy, containing 90 per cent of tin and 10 per cent of antimony is called Alger metal.

Argentite. An important ore of silver, also known as silver glance. It has the composition Ag_2S, and contains theoretically 87.1 per cent of silver. It usually occurs massive, with a hardness of 2 to 2.5. Its color is streaked blackish and lead-gray, with a metallic luster. Argentite is found in Nevada, Arizona, Mexico, Peru, Chile, Bolivia, and in Central Europe.

Argilit. The trade name of a light-weight alloy containing 90 per cent of copper, 2 of silicon, and 2 of bismuth. The silicon in the metal is claimed to give fluidity in pouring, and to produce sound castings. It is employed for automotive engine parts.

Argon. A gaseous element, symbol A, occurring free in the atmosphere to the extent of 0.935 per cent. Its liquefying point is about −187 deg. C. It can be obtained by passing atmospheric nitrogen over red-hot magnesium, forming magnesium nitride and free argon. It forms no known compounds. Its density is about one and a half times that of air. It is employed in filling incandescent electric lamps to give an increased light.

Argyrodite. A silver ore found in Bolivia and in Germany, and especially remarkable as a source of the rare metal germanium, of which it contains from 5 to 7 per cent. The approximate composition of the mineral is $4Ag_2S{\cdot}GeS_2$ when pure.

Arkansas ash. The wood of the ash tree *Fraxinus platycarpa*, which is in reality a species of American ash. It is white or yellowish in color, with a firm texture, and a coarse, open grain. The weight is about 36 lb. per cu. ft. It is native to North America. See Ash.

Armco ingot iron. The trade name of a commercially pure iron having a maximum of 0.16 per cent of impurities. It is a product of the American Rolling Mills Company, Middletown, Ohio. A typical analysis gives: Iron 99.94 per cent, carbon 0.013, manganese 0.017, phosphorus 0.005, sulphur 0.025, and possibly a trace of silicon. It was developed as a rust-resistant material, and is employed extensively in sheets and plates for building construction and for tanks. It is also used for electro-magnet cores, for welding rods, and as a raw material in making tool and special steels. It is made in the basic open-hearth furnace. The specific gravity is 7.858, melting point about 1,530 deg. C., and boiling point 2,450 deg. C. The tensile strength of hot-rolled sheets is up to 48,500 lb. per sq. in., and of cold-rolled rods up to 63,000 lb. per sq. in. See also Ingot iron.

Arsenic. A soft, brittle, and very poisonous element of steel-gray color and metallic luster. The chemical symbol is As. The melting point is 850 deg. C., and the specific

gravity is about 4.8. It is allotropic, with metallic and non-metallic properties, and forms arsenious, arsenic, and acid compounds. When heated in the air arsenic burns to arsenious anhydride with white odorous fumes. The white, poisonous powder commonly known as "arsenic" is arsenic trioxide, As_2O_3. The most common ores of arsenic are the arsenical iron pyrites, realgar, smaltite, and orpiment. Arsenic is also a by-product from the copper smelters. It is obtained by roasting the ores and recovering by distillation. Arsenic is added in small quantities to soft alloys for hardening, and to increase fluidity, especially white bearing metals. It is also added to lead in making shot to diminish its cohesion.

Arsenic disulphide. Also known as red arsenic glass, and red orpiment. It is an orange-red, poisonous powder, of specific gravity 3.5, and melting point 307 deg. C., obtained by roasting arsenopyrite and iron pyrites. It has the composition As_2S_2, and is soluble in acids and alkalies, but insoluble in water. It is employed in fireworks, as a paint pigment, and in the leather and textile industries.

Arsenopyrite. Also called mispickel. The most common mineral containing arsenic, and valued as an ore of arsenic and for obtaining arsenic trioxide. It is found in veins in crystalline rocks associated with ores of tin, silver, lead, and with pyrite, sphalerite, and other minerals. It occurs in quantities in Saxony, in Cornwall, Bolivia, Canada, New South Wales, and in Connecticut. Arsenopyrite is sulpharsenide of iron, FeAsS, containing 46 per cent of arsenic, and 34.3 per cent of iron. It occurs in crystals, or massive, granular to compact. It has a specific gravity of 6.2, a hardness of 5.5 to 6, a metallic luster, and a silvery-white to gray color with black streaks.

Asbestos. The commercial name for a fibrous variety of mineral. It is a Greek word meaning incombustible. The original source of asbestos was the mineral actinolite, but the variety of serpentine known as chrysotile now

furnishes most of the commercial asbestos. The rocks occur compact, but the fibers are easily separated and are fine and flexible. They are woven into fabrics, and compressed with a binding material into fiber boards which are non-combustible and nonconductors of heat. The color is usually white to greenish. Asbestos is employed as a heat insulator on stoves and furnaces, for roofing, as a packing for steam pipes, and for making fire-proof garments for furnace tenders. Such fabrics are made up of long-fiber asbestos with about 25 per cent of cotton thread woven with a herringbone twill weave. When woven with fine metallic wires it is made into brake linings. Blue asbestos, or Cape asbestos, from South Africa, is the mineral crocidolite. Tremolite and actinolite are also employed as asbestos. Canada is the largest producer of asbestos, and in 1926 exported 277,991 tons.

Asbestos paper. A material made of asbestos fibers bonded with a solution of sodium silicate. It is fireproof and a heat insulator, and is used for covering steam pipes and for insulating walls. It is made in flat sheets of 2 and 3 ply, and is also marketed in rolls of 250 sq. ft., 36 in. wide. For wall insulation it is also made double with one corrugated sheet to form air pockets when in place.

Ascoloy. The trade name of a "rustless iron" produced by the Allegheny Steel Company, Breckenridge, Pa. It is a product of the electric furnace, and contains 12 to 16 per cent of chromium, 0.50 per cent each of manganese, nickel, and silicon, and below 0.12 per cent of carbon. It is manufactured in billets, plates, sheets, bars, tubes, wire, and castings. Ascoloy is ductile and malleable, and can be machined about the same as 0.30-carbon steel. The tensile strength is 72,000 to 85,000 lb. per sq. in., and the elongation 25 to 35 per cent in 2 in. The Brinell hardness is 140 to 170. It is highly resistant to atmospheric conditions, corrosion, acids, and is heat-resistant. It is used for tools, pipes, and fittings in mines. It is also employed for pump parts, screw-machine products, kitchen utensils,

and parts requiring a corrosion-resisting material. It resists temperatures up to 2,250 deg. F. without oxidation, and at that temperature retains a fairly high tensile strength. It is made in various grades.

Ash. The wood of a variety of species of ash trees. These woods vary in their qualities, but are likely to be mixed in commercial shipments, or one variety substituted for another indiscriminately. American and Canadian ash come from the trees *Fraxinus americana*, *Fraxinus sambucifolia*, and other species; Arkansas ash from *F. platycarpa;* European ash from *F. excelsior;* and Japanese ash from *F. mandschurica.* American "white" ash, *F. americana*, weighs 41 lb. per cu. ft., dry; "red" ash, *F. pennsylvanica*, 39 lb. per cu. ft.; and "green" ash, *F. pennsylvanica lanceolata*, 44 lb. per cu. ft. These woods vary in tensile strength from 11,000 to 17,000 lb. per sq. in. "Mountain ash" and "black ash" are also species of American ash. Ash is rather hard, with a course, open grain, and a brownish color. It is very tough and elastic. It does not withstand exposure very well. The wood is used for handles, wheels, flooring, carriage building, and interior construction work. The total production of ash in the United States in 1925 was 179,032,000 bd. ft. See also Arkansas ash, and European ash.

Ashberry metal. An alloy resembling Britannia metal, and used for tableware, and utensils. It is somewhat harder than Britannia metal, but is of inferior appearance. A typical composition is: Tin, 80 per cent, antimony 14 per cent, copper 2 per cent, nickel 2 per cent, zinc 1 per cent, and aluminum 1 per cent. Some Ashberry metal contains no nickel, zinc, or aluminum. On account of the poisonous effects of antimony the alloys high in this metal are not considered desirable for utensils for foodstuffs.

Aspen. The wood of the aspen tree, *Populus tremula*, employed chiefly in the manufacture of match stems, and for making excelsior. The color is yellowish, and it is tough

and close-grained. The tree is native to Europe. The aspen of the northern states of the United States is from the tree *Populus tremuloides*, and the lumber is classed with cottonwood. Large-tooth aspen, *Populus grandidentata*, of the northeastern states, is also classed as cottonwood.

Asphalt. A bituminous, black, or brownish substance, solid or semi-solid, found in various parts of the world. It consists of a mixture of hydrocarbons, and is related to petroleum. It usually melts at from 32 to 38 deg. C., and is soluble in turpentine and partly soluble in alcohol. The most noted asphalt deposits are in Trinidad and in Venezuela. The Trinidad asphalt lake covers 100 acres, and is estimated to contain 35,000,000 tons. Trinidad asphalt contains 47 per cent of bitumen, 28 per cent of clay, and 25 per cent of water, and must be refined before use. Asphalt is used for making roofings, insulating varnishes, acid-resisting paints, and in road building. Artificial asphalt is the heavy residue from coal distillation, mechanically mixed with sand, chalk, or limestone. Asphalts known and marketed under various other names are found in the western parts of the United States, and in other countries. See Gilsonite, Albertite, Oil asphalt. Sales of all natural asphalts and related minerals in the United States in 1927 were 839,040 tons.

Atacamite. An ore of copper found originally in Atacama, Chile. It also occurs in Bolivia, Australia, and in Arizona. The mineral is a copper chloride with copper hydroxide, of the formula, $CuCl_2{\cdot}3Cu(OH)_2$, containing 14.9 per cent of copper, 55.8 per cent of cupric oxide, and 16.6 per cent of chlorine. It is generally found in confused crystalline aggregates, fibrous, or granular. The hardness is 3 to 3.5, and the specific gravity is 3.75. The color may be various shades of green. It has a vitreous luster.

Aterite. The trade name of a corrosion-resistant alloy containing copper, nickel, iron, and sometimes zinc, in varying proportions depending on the requirements. The ranges are from 10 to 40 per cent of nickel, 30 to 60 of

copper, 5 to 10 of iron, and 0 to 5 of zinc. It is also resistant to acids and salts, and is used for hardware, valves, and plumbing fixtures. The alloy casts easily, and is also rolled and drawn. The color is nickel-white. The No. 1 alloy contains 65 per cent of copper, 20 of zinc, 11 of nickel, 4 of iron, and 2 of lead. It has a tensile strength of 45,000 lb. per sq. in., and is used for high-pressure castings. The grades for rolling contain only small amounts of iron.

Atha's 2600 alloy. The trade name of a corrosion-resistant and heat-resistant alloy containing approximately 22 per cent of nickel, 8 of chromium, 1.75 of silicon, 1 of copper, 0.70 of manganese, 0.50 of carbon, and the remainder iron. It is covered by the same patent as Rezistal. It is nonmagnetic and is resistant to many acids. Like steel it can be hot rolled into bars and sheets, cold drawn into wire, forged, or cast. It can be machined, but not as easily as steel. It is annealed by quenching in water from a temperature of 1,200 to 1,600 deg. F. The tensile strength annealed is from 95,000 to 125,000 lb. per sq. in., and the elongation 25 to 35 per cent. The tensile strength can be increased only by cold working. The specific gravity is 7.95, and it weighs 0.29 lb. per cu. in. It is a product of the Crucible Steel Company of America.

Auer metal. An alloy of cerium and iron possessing pyrophoric, or sparking, properties. It is used for gas and cigarette lighters. The alloy is named after Auer von Welsbach. The sparking property when struck with steel is due to a superficial layer of oxide. Alloys of cerium with nickel, cobalt, and manganese have this same property. The best sparking results are obtained with 35 per cent of iron and 65 per cent of the cerium earths known as Misch metal. Since the latter is extremely reactive, it is fused either in vacuum or under a fused covering of barium or sodium chloride. The iron is added in loose coils of wire. It is cast at a temperature of 1,000 deg. C. into cylindrical sticks. See also Cerium and Misch metal.

Australian blackwood. The wood of the tree *Acacia melanoxylon*, of Australia and Tasmania. The color is reddish-brown to black, often with streaks. The grain is fine and even, and it takes a beautiful polish. The weight is 36 to 42 lb. per cu. ft. It is employed for cabinet work, interior finishing, and for many other kinds of construction. The Victorian and Tasmanian blackwood is beautifully grained, and is the most highly prized. It is similar in durability and appearance to rosewood.

Australian red mahogany. The wood of the tree *Eucalytus resinifera*, of Australia. It has a dark-red color, is very hard, and has a coarse, open grain. The weight is 61 to 71 lb. per cu. ft. The wood is used for construction work, and for posts and paving blocks. It is very durable in the ground.

Autunite. A secondary mineral formed probably by the action of water on pitchblende. It has been mined in Portugal for the extraction of radium, and is now also produced in Utah. The composition of autunite is approximately $P_2O_5 \cdot 2UO_3 \cdot CaO \cdot 8H_2O$. It is also called Uranite. See also Uraninite.

Azoimide. Also called Iminazoic acid. An extremely explosive substance of the composition $HN \cdot N_2$ used in explosives, and also for dissolving out various metals. It is made by passing nitrous fumes into a solution of hydrazine sulphate. It is a colorless gas with a peculiar nauseous odor. It liquifies at 37 deg. C., and is very soluble in water. The silver salt, $AgN \cdot N_2$, and the mercury salt, are both insoluble in water, and are extraordinarily explosive. Barium azoimide, BaN_6, explodes with a green flash when heated. Iron, zinc, copper, aluminum, and gold dissolve readily in a 7-per cent solution of azoimide.

Azurite. An important ore of copper found widely distributed with other copper ores. It occurs in fine crystals in Arizona, at Chessy, France, and in Siberia. Azurite is a

basic carbonate of copper, $Cu(Cu \cdot OH)_2(CO_3)_2$, containing when pure 55.3 per cent of copper. It occurs in crystals of an azure-blue color, and may be transparent to opaque. Its hardness is 3.5 to 4, and the specific gravity is 3.77. Azurite is also called blue copper carbonate, and chessylite.

Babbitt metal. A general name given to white alloys used for machine bearings. The original babbitt metal was made by melting together 4 parts by weight of copper, 12 of tin, and 8 of antimony, and then adding 12 parts of tin after fusion. It therefore consisted of 88.9 per cent of tin, 7.4 per cent of antimony, and 3.7 per cent of copper. The true babbitt metals are essentially tin-base alloys, but the so-called babbitts are now largely made with higher percentages of lead because of the cost of tin. Almost all white bearing alloys are often referred to as babbitts. Alloys containing 80 per cent of tin or higher should not contain more than 1 per cent of lead for good bearing metals, as the lead does not alloy well. But the lead in small quantities is used to increase fluidity. Alloys containing 0.8 to 1.4 per cent of arsenic are harder at higher temperatures, more fluid, and fine grained. Zinc is considered detrimental to babbitts. Properly made high-tin babbitts are suitable for high-speed bearings for exacting service, but low-grade high-lead alloys are apt to stick to shafts, and do not wear well. The S.A.E. specifications for babbitt for connecting-rod and shaft bearings call for 86 per cent of tin, 5 to 6.5 of copper, 6 to 7.5 of antimony, and not over 0.35 per cent of lead. Babbitts are frequently marketed under trade names such as Stannum, Sabeco metal, Magnolia metal, and Leantin. The consumption of babbitt metals in the United States in 1927 as reported by 31 producers was 60,112,000 pounds.

Baddeleyite. An ore of the metal zirconium. It contains from 68 to 98 per cent of Zirconia, ZrO_2. The chief commercial deposits of the mineral are in Minas Geraes, Brazil. Baddeleyite is the chief source of zirconium, since the cost of reducing it from the mineral zircon is

excessive. It is also a source of zirconia, which is used as a refractory and for making abrasives. See Zirconia.

Bagasse. The residue left after grinding sugar cane and extracting the juice. The shredded fibers are used largely as a fuel in the sugar mills, but the material from the Louisiana sugar industry is also employed for making paper and fiber building board. This manufactured material is sold under trade names, such as Celotex.

Baize. A coarse, loosely woven woolen fabric of plain weave and a short, close nap. It is used chiefly for desk and table covers, box linings, and for shielding bases of instruments. It is usually dyed green. A thin woolen felt of green color used for the same purposes is also called baize.

Bakelite. The trade name of a synthetic resin made by the action of phenol on formaldehyde. It is transparent and amber-like in appearance, can be colored with dyes, and molded into many forms. It is insoluble in water and oils, and is a good electric insulator. It is used to replace hard rubber for electric parts, and for molding various mechanical and ornamental objects. For molding it is subjected to a pressure of 2,000 lb. per sq. in., and a temperature of 350 deg. F. It takes a good polish. The specific gravity is 1.35, and tensile strength is 13,000 lb. per sq. in. It is also furnished in the form of varnishes for coating electric coils and for protecting metal surfaces against corrosion. Combined with paper or fabric it is also made into noiseless gears for machinery. "Micarta" and "Celeron" are Bakelite and fabric compositions. "Fabroc" is Bakelite combined with asbestos, and "Dilecto" is Bakelite with paper. See Phenol-formaldehyde resin.

Balata. A gum obtained chiefly from the tree *Mimusops globosa*, of Venezuela, Brazil, and the Guianas. It is almost identical with gutta percha, and is used as a substitute. It is also used extensively for impregnating

canvas transmission belting to make it moisture proof. It can be vulcanized with sulphur in the same manner as rubber. The annual production of balata is more than 11,000,000 pounds.

Baleen. A trade name for the strips of whalebone used for making whips, canes, and in other places where great flexibility and elasticity are required. See Whalebone.

Balsam fir. The wood of the coniferous tree *Abies balsamea*, of the United States and Canada. The tree grows to a great height. The wood is brownish-white in color, soft, and has a fine, even grain. It is not strong and not very durable, and is used chiefly for packing boxes and light construction. The total 1925 production in the United States was 19,686,000 bd. ft. most of which was cut in northern New England, in Minnesota, and in Michigan.

Balsam poplar. The wood of the tree *Populus balsamifera*, of the northeastern states of the United States. The lumber is usually classed with cottonwood. See cottonwood.

Balsa wood. The wood of the large tree *Ochroma lagopus*, of tropical America and the West Indies. It is one of the lightest of woods, having only about 25 per cent of the weight of spruce, or about 8 lb. per cu. ft. It is used in airplane construction, for life preservers, sounding boards, and where extreme lightness is an important factor, and great strength is not required.

Bamboo. A genus of gigantic tree-like grasses, of the order *Graminaceae*, of which *Bambusa arundinacea* is one of the most common species. It grows most commonly in the East Indies and in Southern Asia. The stems are hollow, jointed, and have an extremely hard exterior surface. They sometimes reach more than a foot in diameter and are often 50 ft. high, growing in dense masses. It is a material of innumerable uses. The stalks are used for making pipes, buckets, baskets, walking sticks, fishing

poles, lance shafts, window blinds, mats, arrows, and for building houses and making furniture. The weight is about 22 lb. per cu. ft. Tali bamboo of Java, *Gigantochloa apus*, is used for construction. Betong bamboo is *G. Asper*, and is one of the largest species. Giant bamboo, *Dendrocalamus gigantea*, of Ceylon, grows to a height of 100 feet. Bamboo also grows in tropical South America.

Barite. Also called heavy spar, and sometimes spelled baryte. A mineral used chiefly for the production of barium hydroxide, but also ground and used as a paint pigment, or as a filler for cloth and paper, though artificial barite, or barium sulphate, is generally employed for these uses. Barite is a barium sulphate, of the composition $BaSO_4$, widely distributed and especially associated with ores of various metals, or with limestones. Notable localities in the United States are: Connecticut, New York, Virginia, Georgia, Tennessee, Missouri, and New Mexico. It occurs in crystals or massive. It may be colorless, white, or light shades of blue, red, and yellow, and transparent to opaque. Its hardness is 3 to 3.5, and the specific gravity is 4.5. See also Barium sulphate.

Barium. A metallic element of the alkaline earth group, chemical symbol Ba. It occurs in combination in the minerals witherite and barite. Barium oxidizes so easily that it is difficult to obtain in the metallic state. It is silvery-white in color, and can be obtained by electrolysis from the chloride. It oxidizes on contact with the air, and decomposes water at ordinary temperatures. Its melting point is 850 deg. C., and specific gravity 3.78. Barium, in the form of its salts, is used as a deoxidizer in purifying alloys of copper, tin, lead, and zinc. Its greatest uses are in its various compounds.

Barium chloride. A colorless, crystalline substance of the composition $BaCl_2 \cdot 2H_2O$, having a great variety of industrial uses, but employed in the mechanic arts chiefly for heat-treating baths, and for making boiler compounds.

The specific gravity is 3.097, and melting point is 860 deg. C. For heat-treating baths for steel parts, it is usually mixed with about 25 per cent of potassium chloride, KCl, in order to reduce the melting point. The baths can be raised to almost any temperature required for hardening heats for steels. It is valued for this purpose, also, as it is inexpensive, and free from fuming. In the automobile industry it is largely used for baths at about 750 deg. C. for normalizing steels.

Barium nitrate. A white, crystalline powder of the composition $Ba(NO_3)_2$. It is a barium salt of nitric acid, and is obtained commercially by roasting powdered barite with coke which reduces the barium sulphate to barium sulphide. This is leached out with water and precipitated as a carbonate by the addition of soda ash. The carbonate is then dissolved in dilute nitric acid. The salt is easily soluble in hot water, and melts at 575 deg. C. The specific gravity is 3.24. It has a bitter, metallic taste. Barium nitrate gives a beautiful pale green flame in burning, and is used for green signals and flares, and for white flares in which the delicate green is blended with the light of other extremely luminous materials. It is also used as a source of oxygen for pyrotechnic compositions.

Barium sulphate. Also called artificial barite, and permanent white. A white, crystalline, poisonous powder of the composition $BaSO_4$, used as a paint pigment. It is found in nature in the impure state as the mineral barite. It is made by the action of sulphuric acid on solutions of barium salts. It is also employed as a sizing for paper, and as an adulterant of saffron. For all of these uses it is finely ground. The specific gravity is 4.48. It is insoluble in water.

Barwood. The wood of the tree *Pterocarpus santalinus*, native to West Africa. The wood has a bright-red color, a close texture, is hard, and takes a fine polish. It is used as a dyewood, and also for tool handles. The weight is 54

lb. per cu. ft. The commercial logs are generally very short. The wood of the tree *Baphia nitida*, of Sierra Leona, is also called barwood, and is used as a red dyestuff. Both woods contain a coloring material of the composition $C_{24}H_{22}O_8$, known as santalin.

Basalt. A dense, hard, dark-brown to black igneous rock, consisting of feldspar and augite, and often containing crystals of green olivine. It occurs as trap or as volcanic rock. The specific gravity is 2.87 to 3. Masses of basalt are frequently found in columns or prisms, as the celebrated basalt cliffs of North Ireland. Basalt is often wrongly classed as a granite. It is widely used in the form of crushed stone for paving.

Basic pig iron. Pig iron containing only small amounts of silicon and sulphur, so that it is suitable for easy conversion into steel by the basic open-hearth process. The silicon is apt to dissolve the basic furnace lining, and if possible is kept as low as 0.70 to 0.90 per cent. The sulphur is not usually over 0.05 per cent. The name is usually restricted to pig iron containing not more than 1 per cent of silicon. See Pig iron.

Bass. A coarse fiber obtained from the leaves of the palm tree, *Raphia vinifera*, of West Africa. It is similar to raphia, and is used for making mats, baskets, and also employed for hand brushes, and for heavy brooms for street sweeping.

Basswood. The wood of several species of lime trees, *Tilia americana*, *T. heterophylla* (white basswood), *Tilia glabra*, and *T. pubescens*, all native to the United States and Canada. The European lime-tree, *Tilia cordata*, is not called basswood. Basswood is soft, light in weight, and has a fine, even grain. The weight is 30 lb. per cu. ft. The color is white. It is not very strong. It is used for turning, musical instruments, inner soles of shoes, and a variety of other articles. It is also used for making excelsior. The

production of basswood in the United States in 1925 was 179,642,000 board feet.

Bathite. The trade name of an artificial corundum, or aluminum oxide, used as an abrasive, and as a refractory material. It is a product of the White Heat Products Co., West Chester, Pa. See Aluminum oxide.

Bauxite. A mineral which is an important ore of the metal aluminum, and is also used for the manufacture of artificial abrasives, aluminum salts, and refractory brick. About 75 per cent of the production in the United States is for metallic aluminum. The largest producers are: Arkansas, Georgia, and Alabama. Bauxite is a non-crystalline, earthy mineral, massive or in grains. Its composition is $Al_2O_3 \cdot 2H_2O$, and it contains theoretically 73.9 per cent of alumina, with 26.1 per cent of water. Its color is white, gray, yellow, or red. It derives its name from Baux, France. American bauxite has usually a round, pebble-like structure, and the commercial grades should have at least 52 per cent of alumina, and not more than 15 per cent of silica and iron together. Bauxite melts at 1,820 deg. C. See also Aluminum oxide.

Baywood. A name given in the English trade to a plain, straight-grained mahogany. The name is supposed to have been applied originally to the superior mahogany from the shores of the Bay of Honduras, in contradistinction to the "Spanish mahogany" from the West Indies. See Mahogany.

Bearing metals. Almost any commercial metal can be used for machinery bearings if required, but certain metals and alloys are particularly fitted for use as bearing metals chiefly because of the fact that a proportion of hard crystals is formed in a background, or matrix, of softer metal. These hard crystals project from the matrix and support the shaft, decreasing the continuous frictional area and permitting free circulation of the lubricant. In the soft "babbitt" metals these crystals are formed largely by the

antimony, leaving the lead as a matrix. In the bronzes the crystals consist of a chemical compound of copper and tin, leaving the excess tin and copper as the matrix. Antimony is also used in bearing bronzes, especially for car axles. Cast iron is an excellent bearing metal because of the hard carbides, a soft background of iron, and considerable graphitic carbon, which in itself is a lubricant. For ordinary service, babbitts and the soft white alloys are used, but they will not withstand high pressures or temperatures. For severe service conditions bronze bearings are used. Unlike metals are almost invariably employed for shaft and bearing, and the wear is usually taken in the bearing. Self-lubricating bearings are of bronze with oil-impregnated wood inserts, or bronze cast with a percentage of graphite. See also Babbitt, Bronze, Genelite, Ajax metal, Lumen alloys, Parock.

Bearingoy. The trade name of a "babbitt" alloy used for machinery bearings. It is a product of The Williams Alloy Products Company, Elyria, Ohio. The melting point is 465 deg. F., and the pouring temperature is 800 to 925 deg. F. The Brinell hardness is about 26. Bearingoy is claimed to give long service even under poor lubricating conditions. See also Babbitt metal.

Beech. The wood of several species of beech trees *Fagus atropunicea*, *F. ferruginea*, and *F. grandifolia*, common in the eastern parts of Canada and the United States. The wood is strong, compact, fine-grained, very durable, and of a light color. The weight is 47 lb. per cu. ft. It is employed for tool handles, shoe lasts, gunpowder charcoal, and for making wooden articles such as clothes pins. The trees grow to a height of 100 ft., and 4 ft. in diameter. The production of beech in the United States in the year 1925 was 80,585,000 bd. ft. Antartic beech, *Fagus antarticus*, known locally as rauli, grows extensively in Chile and Western Patagonia, and is employed for barrel staves, and in place of oak. European beech, *Fagus sylvatica*, is reddish-brown in color, and has a close, even texture. The wood is

not very durable, but as it is tough, elastic, and takes a goo polish, it has a great variety of uses for tools, furnitur and other articles. The weight is 43 lb. per cu. ft. Ne Zealand beech, *Fagus solandri*, and *Fagus fusca*, has a weigh of 47 lb. per cu. ft., is brownish in color, is hard, and claimed to be superior to all other beeches in strengt and durability.

Beeswax. The wax formed and deposited by the hone bee, *Apis mellifica*. The bees build "combs" for the rece tion of the honey, consisting of two sheets of horizonta six-angled prismatic cells formed of wax. After the extra tion of the honey, the wax of the combs is melted an molded into cakes. New wax is light-yellow in color, bu turns brown with age. It is bleached by sunlight or wi acids. The specific gravity is 0.965 to 0.969, and the mel ing point 63 deg. C. Beeswax is used for covering steel other metals to be etched, for floor waxes, candles, an molded articles. It is very frequently adulterated wi paraffin, stearine, Japan wax, or other vegetable waxe and the commercial article may be as low as 50 per ce pure.

Bell metal. A bronze used chiefly for casting large bel The composition is varied to give varying tones. T standard is 78 per cent of copper and 22 per cent of ti It weighs about 0.312 lb. per cu. in. Increasing the copp slightly increases the sonorous tone. This alloy is yellowis red, has a fine grain, is easily fusible, and is the approxima composition of the fine-toned gongs. Large bells are ma of 75 per cent copper and 25 per cent of tin. Another b metal contains 77 per cent of copper, 21 per cent of t and 2 per cent of antimony, and is harder, giving a shar tone. Silver bell-metal, for small bells of "silvery" tone, i white metal containing about 40 per cent of copper and per cent of tin.

Belt dressings. Compounds employed to soften a improve the surface of belts that are used to drive mach

ery. They are usually compounded of some of the following: Waxes, degras, fats, tallow, castor oil, fish oils, and corn oil. They may also contain sulphonated oils or rosin. Castor oil or neatsfoot oil in the dressing acts as a lubricant. Mineral oils are claimed to be injurious. Rosin, and resinous substances are put into some dressings to make the belt grip or adhere to the pulley surface, but they make the belt dry and fill the pores so that it cannot be lubricated. Belt dressings are marketed under a great variety of trade names, and trial tests should be made if the ingredients are not given.

Benedict metal. A corrosion-resistant white alloy which has been used for condenser tubes, fancy building hardware, and parts of chemical machinery. It generally contains about 85 per cent of copper, 14.5 per cent of nickel, and traces of iron, manganese, and other impurities. Its tensile strength is about 47,000 lb. per sq. in. It may contain as high as 22 per cent of nickel. Where color is important it should not contain zinc because of the "dezincification" and change of color on long exposure. See also Cupro-nickel.

Benzene. Also called benzol. A hydrocarbon product of coal tar, and not to be confused with petroleum ether, or benzine. See Benzol.

Benzine. A light petroleum product which distills off just before the gasoline products. It ranges between C_5H_{12}, and C_6H_{14}. It is called also petroleum ether, and is distinct from benzene. Benzine is used as a fuel, as a solvent, and as a cleanser. It has a specific gravity of from 0.635 to 0.660, and a boiling point from 40 to 70 deg. C. It is obtained commercially by the fractional distillation of petroleum, washing with sulphuric acid and with soda, and redistilling.

Benzol. Also called benzene. An aromatic hydrocarbon product of coal tar used as a fuel for airplane engines. It is an excellent solvent for rubber, waxes, camphor, and other organic materials. It is also used for making aniline, and as a cleanser. As an automotive motor fuel it gives 10 to

15 per cent more mileage than gasoline when properly vaporized and mixed with air. Benzol is a brilliant, colorless, highly-inflammable liquid with a characteristic odor. The composition is C_6H_6, the specific gravity is 0.878, boiling point 97.7 deg. C., and solidifying point 5.5 deg. C. It is insoluble in water, but soluble in alcohol. It is obtained commercially in the manufacture of illuminating gas by passing the gas through oil and then distilling.

Benzyl alcohol. A colorless liquid of the composition $C_6H_5CH_2OH$, used as a solvent for lacquers, gums, and paints. It has a faint aromatic odor, is soluble in water, and boils at 206 deg. C. It has also uses in perfumery manufacture, and as a local anesthetic. Benzyl alcohol is made by the action of potassium hydroxide on benzaldehyde.

Benzyl bromide. A lachramatory poison used in chemical warfare. It is made by mixing bromide and toluene, and has a composition of $C_6H_5CH_2Br$. It is a colorless liquid with a specific gravity of 1.438, and a boiling point of 198 deg. C. In mixtures with xylyl bromide it was much used by the Germans under the name of T-stoff. The benzyl bromide made by the Germans contained also benzylidene bromide, $C_6H_5CHBr_2$. It had a boiling point of 215 deg. C., and a specific gravity of 1.3. Benzyl bromide vapor causes a copious flow of tears. See also Poison gases.

Benzyl chloride. A colorless, aromatic liquid of the composition $C_6H_5CH_2Cl$, used as a lachramatory poison in chemical warfare. It is made by the chlorination of toluol. The specific gravity is 1.103, and boiling point is 179 deg. C. Benzyl dichloride has the composition $C_6H_5CH{\cdot}Cl_2$, a specific gravity of 1.295, and boiling point of 212 deg. C. These compounds are thrown in high-explosive shells, and disseminated as mists. See Poison gases.

Bersch metal. A trade name for a light metal used for bearings. It contains 93 per cent of aluminum and 7 per cent of nickel. The nickel forms the chemical compound $NiAl_3$, which gives the crystalline structure necessary for a

bearing, and the excess aluminum forms the softer background.

Beryllium. An elementary metal, symbol Be, which belongs to the group of light metals, and is expected to find extensive industrial application as soon as it can be produced cheaply. It is sometimes also known as glucinum. The metal is hard, brittle, and crystalline, but it alloys well with aluminum. It has a grayish-steel color, and polishes well. It does not corrode easily, as an oxidized film protects it from further oxidation. It has a specific gravity of 1.84, its weight being only about 70 per cent that of aluminum. It melts at 1,285 deg. C. The scratch hardness is 6 to 7 on the Moh scale. Beryllium occurs in the emerald and in other forms of the mineral beryl, varieties of which are used as gemstones. In 1922 it sold for $5,000 per pound, but is now produced from common varieties of beryl at about $50 a pound. It is employed in alloys with aluminum. An alloy of 5 per cent of beryllium and 95 per cent of aluminum has a higher melting point and is lighter than aluminum. It is also stronger, and machines more easily. The usual aluminum-beryllium alloys at present contain less than 1 per cent of beryllium.

Bessemer steel. Steel made by blowing air through molten pig iron, the cold air under high pressure being blown in small streams through the mass thus reducing the amounts of silicon, manganese, and carbon to very low percentages. The process was developed by Henry Bessemer in England in 1860. The chemical reaction from the air increases the temperature of the molten metal, and forms the chief fuel as the carbon is oxidized and driven off. The process requires only about six minutes, and the carbon is reduced to 0.04 per cent or less. The lining of an "acid" converter is made of a highly refractory acid material, usually ganister or mica shist. The converters vary from 5 to 25 tons capacity, a common size being 18 tons. Acid Bessemer pig iron should contain about 1 per cent of silicon, but the sulphur and phosphorus should be low since they are not removed in

the process. In the final steel a content of 0.09 to 0.13 pe cent of phosphorus and 0.075 to 0.15 per cent of sulphur ar desired to make machinery steel that will be free cutting an keep the chips from curling. Contents as high as these ar not suitable, however, for structural steels. The carbo content is made as desired by the addition of carbon to th crucible. For "basic" Bessemer steel the converter has basic lining of burned dolomite, and the pig iron has les silicon to avoid the production of much silica. High phosphorus pig irons are made into steel by this process a the basic lining aids in the elimination of the phosphoru and sulphur. Lime is also put in at the beginning of th blow. The basic process is not used in the United State but is employed in England and Germany.

Bidery metal. An ancient alloy originally used in Indi for making utensils. It does not oxidize easily. It composed of 31 parts of zinc, 2 of lead, and 2 of coppe melted with resins to prevent oxidation. The velvety black color imparted to the utensils is done by treatmen with a solution of copper sulphate.

Birch. The wood of the birch trees *Betula alba*, the whit birch; *Betula lenta*, the sweet birch; *Betula nigra*, river birc *Betula lutea*, yellow birch; and others, grown in Nort America, Europe, and Asia. Black birch, Russian mapl and silver birch are other varieties. The wood has yellow or yellowish-red color, is tough and hard. Th texture is close. The weight is about 40 lb. per cu. f Birch is used in construction work, especially for doors ar trim. It is also valued for furniture and general uses ar is frequently employed for the turned parts of foundr patterns. Birch lumber usually includes the wood several species. The production in the United States 1925 was 412,229,000 board feet.

Birch oil. A yellowish, posionous, essential oil with characteristic odor, obtained by distillation from birch ta which is a product of the dry distillation of the wood

the white birch tree, *Betula alba*. The specific gravity is 0.956. It is employed in dressing fancy leathers, and as a disinfectant, and is distinct from the sweet birch oil known as Betula oil.

Bismuth. An elementary metal, symbol Bi, occurring in small quantities native in Sweden, Saxony, England and Canada. American bismuth is obtained as a by-product in the refining of lead and copper, and amounts to nearly half of the world's production of 300 tons annually. Foreign bismuth comes largely from the mineral bismuthinite obtained from Bolivia and Australia. Bismuth has a grayish-white color with a reddish tinge. It is very brittle, and powders or crystallizes easily. The specific gravity is 9.75 and its melting point is 507 deg. F. Bismuth has the property of expanding when changing from the liquid to the solid state. This makes it valuable in type-metal alloys where it aids in filling the mold and making a fine impression. Bismuth also lowers the melting point of alloys, and finds use in alloys of tin and lead for soft solders and plugs for fire sprinklers. It is also used in babbitts.

Bismuth chromate. An orange-yellow powder of the composition $Bi_2O_3 \cdot 2CrO_3$, employed as a pigment. It is made by the interaction of bismuth nitrate and a potassium chromate. It is insoluble in water, but is soluble in acids and in alkali solutions.

Bismuthinite. An ore of the metal bismuth, found in Bolivia, Germany, England, Sweden, and in parts of the western United States. It is a bismuth trisulphide, Bi_2S_3, containing theoretically 81.2 per cent of bismuth. It has a massive foliated structure, with a metallic luster and a lead-gray streaked color. Its hardness is 2. The concentrated ore is roasted, and then smelted with carbon. The resulting impure bismuth is refined by an oxidizing fusion.

Bismuth oxychloride. Also known as pearl white. A white, lustrous, crystalline powder employed as a paint pigment. It has the composition BiOCl, specific gravity

7.717, and is insoluble in water. It is produced by the action of water on bismuth chloride. See Pigments.

Bismuth solder. Bismuth is sometimes added to tin-lead solders to lower the melting point, and also to make the solder more fluid. The proportions vary, depending upon the melting point desired. A solder containing 1 part of tin, 1 of lead, and 1 of bismuth melts at 284 deg. F. It is harder than ordinary tin-lead solder. See Solder.

Bitumen. The organic matter contained in asphalt, gilsonite, raphaelite, and other asphaltic products, but the general use of the term also includes the natural asphalt product with its content of sand and water. It is also extended to include any inflammable mineral substances consisting chiefly of hydrocarbons, including mineral tars and coal-tar pitch. A characteristic of bitumen is that it is totally soluble in carbon disulphide.

Bituminous coal. Also called soft coal. A variety of coal with a low percentage of carbon, and easily distinguished from anthracite coal by the properity of losing moisture readily on exposure and breaking up into small pieces. The bituminous coals vary in quality from near lignite to the hard grades near anthracite, called semi-bituminous. The specific gravity of clean bituminous coal is 1.75 to 1.80. It is found in 28 states of the United States, and the estimated American reserves are 14 hundred billion tons. It is the coal used almost exclusively for industrial purposes. The best steam coals are the semi-bituminous grades from West Virginia, Virginia, Pennsylvania, and from some parts of the Middle West. Good coal for industrial use should give 13,500 to 14,500 B.t.u. per lb., have from 55 to 60 per cent of fixed carbon, 30 to 37 per cent of volatile matter and a ratio of fixed carbon to volatile matter of from 6.5 to 1. The better grades are in large lumps. Fine coal is called slack. See also Coal, Anthracite.

Blackbutt. The name applied to the wood of at least two of the many species of eucalyptus trees native to Australia

but now grown in other countries. These include *Eucalyptus pilularis* and *E. patens*. The wood is gray or dull-brown in color, is hard, close-grained, and dense. It weighs about 58 lb. per cu. ft. It is tough and durable, but is inclined to warp and crack. Blackbutt is used in construction locally, and has been exported as a substitute for oak.

Black cottonwood. The wood of the tree *Populus trichocarpa* of the Pacific Coast of the United States. The lumber is usually classified under the general name of cottonwood. See Cottonwood.

Blackfish oil. A pale-yellow oil extracted from the "pilot whale," or dolphin, *globicephalus melas*, found off the North Atlantic coast as far south as New Jersey. The oil is used in lubricating and cutting oils. The product from the head and jaw is of the best quality, and is known as jaw oil. It is used as a lubricant for fine mechanisms. The saponification value is 290, iodine value 27, and specific gravity 0.929. The blackfish averages 15 to 18 ft. in length, with a weight of about 1,000 lb. The body oil is also employed in lubricants, and for treating leather. See also Whale oil.

Blanc fixe. A trade name for finely ground barium sulphate, used as a pigment for paints and also in printing inks. See Barium sulphate.

Bleaching powder. A name frequently used to designate chloride of lime. But commercial bleaching powder may also be a mixture of calcium hypochloride and calcium hypochlorite. It has wide general industrial use as a strong disinfectant, and as a cleansing and bleaching agent.

Blister copper. The name given to the copper pigs which are cast in the molds directly from the converter. The pigs of blister copper contain from 96 to 99 per cent of copper, the impurities being sulphur, nickel, arsenic, antimony, iron, lead, selenium, and tellurium, with sometimes gold and silver. The name is derived from the blistered appearance of the upper surface of the pigs due to the sul-

phur dioxide escaping when the copper is solidifying. Blister copper is not used commercially, but is refined in furnaces or electrolytically.

Blister steel. The name applied to the bars removed from the carbonizing boxes in the process of making steel in the cementation furnace. The surface of the bars is covered with blisters caused by the reaction of the carbon in the metal with the iron oxide of the slag. Blister steel has a crystalline fracture decreasing toward the center of the bar where there is less carbon. It is used for rolling into commercial bar iron or shear steel.

Blown oils. Fatty oils that have been oxidized by blowing air through them. They are mixed with mineral oils to form special heavy lubricating oils such as marine engine oil, or are employed in cutting oils. They are also used in paints and varnishes as the drying power is increased by the oxidation. The flash point and the iodine value are both lowered by the blowing. The oils usually blown are: Rapeseed, cottonseed, fish and whale oils.

Blue vitriol. The common name for hydrous copper sulphate used for coppering steel for layout work, for wet electric battery solutions, in dyestuffs, germicides, and in various manufacturing processes. See Copper sulphate.

Bobierre's metal. An old trade name for a ductile yellow alloy of 66 per cent of copper and 34 per cent of zinc. It is now effectively replaced by the standard brasses of the mills. See Brass.

Bog-iron ore. A common name for a secondary ore of iron formed by the decomposition of iron minerals and carried by water into marshes. See Limonite.

Boiler compounds. Chemicals employed for the internal treatment of water in steam boilers to prevent the formation of scale and the foaming of the water. They are distinct from water softeners that are used to extract the undesir-

able chemical compounds from the water before it is put into the boiler. Sodium salts are most extensively employed in compounds. They convert the sulphate of calcium and magnesium into sulphate of soda, the calcium and magnesium being precipitated as a sludge which is removed by blowing down. The sodium sulphate is highly soluble and does not deposit. Most of the boiler compounds sold under trade names contain soda ash and caustic soda. Some also contain tri-sodium phosphate and sodium silicate, and many contain tannin extracts or some other organic matter. Indiscriminate use of boiler compounds is a costly procedure. Water softening is generally considered preferable, but where this is not possible the content of the compound should be known, and controlled to suit the feed water conditions.

Boiler plate. Originally iron or steel plate used for making steam boilers, but now a name in general shop use referring to any iron or soft steel plate or heavy sheet. True boiler plate usually includes the thicknesses from No. 10 gage, approximately $\frac{9}{64}$ in., to 2 $\frac{1}{2}$ in., but No. 12 gage and thinner are referred to as sheet. Boiler plate is divided into fire-box, flange, and extra-soft. Firebox plates should contain not over 0.30 per cent of carbon, 0.30 to 0.50 of manganese, and not over 0.04 per cent each of phosphorus and sulphur. Flange plates should contain less carbon. The tensile strength is from 55,000 to 65,000 lb. per sq. in. A 3-per cent nickel steel is also used for high-pressure boiler plate. It contains from 2.75 to 3.25 per cent of nickel, 0.40 to 0.80 per cent of manganese, not over 0.20 per cent of carbon, and a maximum of 0.045 each of phosphorus and sulphur. The ultimate strength is above 70,000 lb. per sq. in., and the elongation 26 per cent in 2 in. It resists corrosion better than ordinary boiler plate. Boiler plate is now also made regularly in manganese steels, and from highly refined ingot irons, such as Toncan iron, containing copper, molybdenum, or other elements.

Bolting cloth. A fine, strong, silk cloth of very open weave, used industrially for sifting finely pulverized mate-

rials. It is made almost entirely on hand looms, and comes largely from Switzerland.

Bone black. Charred bone or ivory, ground to a fine, silky powder, and used as a pigment, especially for inks. It has a deep, dense, bluish-black color, and its depth and tone is valued for engraving inks, but its covering power is much inferior to that of carbon black. It is also used as a decolorizing agent for oils. Bone black is made by calcining bones in air-tight retorts after they have been freed from fat and ground to a course powder. The specific gravity is 2.6 to 2.8. It has a low carbon content, and an ash content sometimes as high as 80 per cent. The best blacks are treated with acid to remove the lime salts, and they will not settle out of the oils or paints. Drop black is the spent bone black from the decolorizing of sugar, which has been washed and reground. It is substituted for bone black.

Borax. A white or colorless crystalline mineral used as a flux or solvent for metallic oxides in soldering and welding, and as a flux in smelting. It is also used in scouring and cleaning compounds, as an antiseptic and preservative. It is a hydrous sodium borate of the composition $Na_2B_4O_7 \cdot 10H_2O$, containing 47.2 per cent of water. It has a hardness of 2 to 2.5, and specific gravity of 1.75. It is easily soluble in water. Borax is found in great quantities in the desert regions of the western states, and in the Andean deserts of South America.

Borcher's metal. A group of alloys valued for their corrosion-resistant and acid-resistant properties. They will also resist oxidation at elevated temperatures. The basis of the alloys is chromium, with from 30 to 65 per cent of this metal. One grade contains 30 per cent of chromium, 35 of cobalt, and 35 of nickel. Another grade contains 36 per cent of chromium, 60 of iron, and 4 of molybdenum, while still another contains 65 per cent of chromium and 35 of iron.

Boric acid. Also called boracic acid, and orthoboric acid. A white, crystalline substance of the composition

H_3BO_3. It is used as a flux in soldering and brazing, as a preservative, in glass and pottery manufacture, and as a weak antiseptic. It is also employed in quenching baths for "boronizing," or surface-hardening steels. The specific gravity is 1.435, and melting point 184 deg. C. It is soluble in water and in alcohol. It occurs naturally in the volcanic districts of Italy where it issues from the ground in the form of vapor. It is also made commercially by adding hydrochloric or sulphuric acid to a solution of borax, and crystallizing. Boric acid is marketed in crystals or in powder.

Borite. The trade name of an artificial aluminum oxide made in the electric furnace, and used as an abrasive. It is a product of the Vitrified Wheel Company, Westfield, Mass. See Aluminum oxide.

Borneol. Also known as Borneo camphor. A white, crystalline substance used as a substitute for camphor in making celluloid. It is obtained from the "kapor" tree *Dryobalanops camphora* of Borneo and Sumatra, and occurs also in some essential oils. Borneol has a specific gravity of 1.01, a melting point of 208 deg. C., and is soluble in alcohol and slightly soluble in water. It has an aromatic, pepper-like odor. The composition is $C_{10}H_{18}O$. It can be made from true camphor by reduction with hydrogen.

Bornite. An important ore of copper. It occurs as a mineral in massive form having a bronze color which turns purple on exposure. It has a metallic luster, and a hardness of 3. The theoretical composition is Cu_5FeS_4, with 63.3 per cent of copper, but it varies greatly due to impurities, the copper content ranging from 55 to 71 per cent. It is widely distributed, and is worked for the production of copper in Chile, Peru, Mexico, Canada, and in various parts of the United States. It is also known under the popular names of horseflesh ore, peacock ore, and variegated ore.

Borolon. A trade name for an artificial abrasive produced by The Abrasive Company, Philadelphia. It is an

aluminum oxide made in the electric furnace. See Aluminum oxide.

Boron. An element, symbol B, closely resembling silicon. Boron compounds are used as fluxes and deoxidizing agents in melting metals. It also is used to give great hardness to steels, and with aluminum forms an extremely hard abrasive. Boron is never found in nature in the pure state, but only in combination. Its best known compounds are boric acid and borax. Boron, when produced pure, is in the form of very hard red crystals, or as a brownish amorphous powder. The specific gravity of the latter is 2.45. At about 600 deg. C. it ignites and burns with a brilliant flame. Boron is obtained by the electrolysis of fused boric oxide, or by heating boric oxide with powdered magnesium.

Boron diamond. An extremely hard crystalline product obtained by melting amorphous boron with aluminum at a temperature of about 1,000 deg. C. The specific gravity is 2.68, and the hardness is about 9 on the Moh scale. It is used for abrasive purposes.

Boron steel. An alloy steel containing a very small percentage of boron, and notable for its great hardness. More than 0.8 per cent of boron renders the metal brittle and unworkable. A remarkable characteristic of boron steels is that they remain plastic like molasses or dough in the mold until they have cooled below the melting point of ordinary cast iron. They are hot-short, and can only be worked at low temperatures. Boron steels are suitable for case-hardening by the nitriding process, as the nitrogen forms a boron nitride and is easily absorbed.

Bort. A name used to designate diamonds of inferior quality that are used for abrasive purposes. It includes stones that have a radiating crystallization which will not take a fine polish and therefore cannot be used as gemstones. It also includes an amorphous variety of diamond in brown, gray, or black colors, known as black diamonds,

and found in Brazil in association with gem diamonds. The amorphous diamonds are also extensively used in diamond drills and cutting tools. The usual sizes are up to 4 carats. Bort is largely imported from France, Belgium, and England, where the diamonds are prepared.

Boxwood. The wood of the tree *Buxus semperrirens*, native to Europe and Asia, but also grown in America. It is used for rulers, instruments, engraving blocks, inlay work, and tools. The wood is light yellow in color, is hard, has a fine grain and a dense structure. It seasons well and does not warp easily. The weight is about 65 lb. per cu. ft. The African boxwood comes from the tree *Buxus macowani*, of South Africa, and is quite similar to the true boxwood. The name is also applied to the wood of the tree *Gonioma kamassi*, of South Africa.

Brass. An alloy of copper and zinc, although some brasses may also contain other elements. Brasses are more ductile than corresponding copper-tin alloys, or bronzes, but are not as hard, and do not contain the hard tin-copper crystals that make bronzes valuable as bearing metals. When the zinc content exceeds 45 per cent, however, the brass becomes very brittle. More than 75 per cent of all commercial wrought brass contains about 65 per cent of copper and 35 of zinc, but many brasses of other compositions are regularly on the market. Brass varies in color from silvery-white to reddish, depending on the amount of copper. Common grades are yellow. The average weight is 0.302 lb. per cu. in. A 65-per cent copper brass has a tensile strength of about 40,000 lb. per sq. in. when cast. "Red brass" contains 85 per cent or more of copper and is more resistant to corrosion. Brasses are made in different standard degrees of hardness or "temper." This hardness is obtained by cold rolling after the last annealing, and the degree depends upon the percentage of cold reduction. When the thickness is reduced one number of the B. & S. gage, the resulting sheet is known as ¼ hard. Other grades are: ½ hard, ¾ hard, hard, extra hard, spring hard, and

extra spring hard. The latter is obtained by the reduction of 10 numbers in the final rolling. Degrees of softness in annealed brass are measured by the grain size. The three standard degrees are: Dead soft, soft, and light annealed. Small amounts of tin are sometimes added to brasses for hardening and to improve the color. Lead in very small quantities improves the cutting qualities, but reduces the ductility. Yellow casting brass usually contains about 2 per cent of lead, and is free-cutting. It is very resistant to corrosion. Brass containing more than 25 per cent of zinc is apt to season crack if exposed to the corrosive action of ammonia or various salts. Iron hardens the alloy and makes it better suited for forging, but makes it difficult to machine. Brass is annealed for drawing and bending by quenching in water from a temperature of about 1,000 deg. F. See also High brass, Cartridge brass, Leaded high brass, Clock brass, Naval brass, Muntz metal, Low brass, Rich low brass, Forging brass, White brass, Aich's metal.

Brazil wood. The wood of the trees *Cæsalpinia brasileinsis*, *C. crista*, and *C. echinata*, of South and Central America, and of *C. sappan*, of Asia and the East Indies. The wood is used chiefly as a dyewood and for a pigment. It contains a coloring matter, brasilein, $C_{16}H_{12}O_5$, which produces purple shades with chrome mordant, and crimson with alum. The wood has a rich, bright-red color and takes a fine, lustrous polish. The best pieces are used for violin bows and various other articles.

Brazing metal. A common shop name for a red brass alloy, low in zinc, used for the casting of such things as flanges that are to be brazed on copper pipe. The government specifications for brazing metal call for 84 to 86 per cent of copper and 14 to 16 per cent of zinc. Some alloys also contain about 1 per cent of lead to make machining easier. The alloys are tough, ductile, and braze easily, but are difficult to cast. A brazing metal marketed by the American Brass Company melts at 1,634 deg. F., and has

a tensile strength, annealed, of 50,000 lb. per sq. inch. It comes in round welding rods.

Brick. The most ancient of all artificial building materials. Bricks are blocks of hard-burned clay, employed for construction. Brick clays are of two general classes. The first consists of non-calcareous clays or shales composed of true clay with sand, feldspar grains and iron compounds, and which when fired become buff, red, or salmon in color. The second class comprise calcareous clays containing up to 40 per cent of calcium carbonate, and are called marls. When fired they are yellowish. Brick clays of the first class are widely distributed. Iron oxide varies from 2 to 10 per cent, and the red color depends largely on this content. In practice the composition of bricks varies widely. Sand-lime bricks, or silica bricks with lime bond, are used for firebricks. See Firebrick, Refractories, and Chromite. The common standard for building brick size is 8¼ by 4 by 2½ in., but other sizes are also used. Paving bricks are either 3 by 4 by 8½ or 3½ by 4 by 8½ in. Bricks are now almost entirely made by machine, the clay being ground and tempered. They are made by pressing soft, stiff, or dry. After drying, the burning is done in kilns at temperatures of from 900 to 1,250 deg. C. The calcareous clays require a temperature up to 1,200 deg. C. to bring about proper chemical combination. The bricks are sorted according to hardness and color, both largely resulting from their position in the kiln. The hardest bricks are used for paving. The common hard brick has a crushing strength of 5,000 to 8,000 lb. per sq. in., and weighs 125 lb. per cu. foot.

Bristles. The stiff hairs from the back of the hog, used in making brushes. The best bristles do not include hair from the sides of the animal, nor the immature product from the slaughterhouses, and come from hogs grown in cool or temperate climates.

Bristol brass. A general trade name for an alloy which is a yellow brass, containing from 60 to 75 per cent of

copper and the balance zinc. It is also called Prince's metal. It is now replaced by the standard brasses of the mills. See Brass.

Britannia metal. A tin-antimony alloy used largely for utensils. It may be considered as a tin hardened with antimony, although some grades of Britannia metal also contain copper and sometimes small quantities of lead. The color is silvery-white with a bluish tinge. It takes a fine polish, and does not tarnish easily. When well proportioned it is easily worked by stamping, rolling, or spinning. It is usually silver plated with a plate of sufficient thickness to withstand cleaning and scouring. The ordinary composition is very similar to that of some Babbitts, tin 89 per cent, antimony 7.5 per cent, and copper 3.5 per cent. Zinc is injurious, and drosses the metal. The composition of "English Britannia" is 94 per cent tin, 5 per cent antimony, and 1 per cent copper. Other mixtures under various trade names are also used, and a small amount of bismuth may also be added. As lead is a poison it is not ordinarily used, and because of the poisonous character of antimony the high-tin alloys are considered preferable for utensils for foodstuffs.

British gum. A trade name for dextrin when used as an adhesive paste. See Dextrin.

Bromine. An elementary substance, symbol Br. It is a dark reddish-brown liquid, having a specific gravity of 3.188, and boiling point of 58 deg. C. It gives off very irritating fumes, and is highly corrosive. Bromine is used in the manufacture of gases for chemical warfare, in dyes, in photographic chemicals, and in bromides for a great variety of uses. It never occurs free in nature, but is made by the electrolysis of salt solutions.

Bromoacetone. A lachramatory poison used in chemical warfare. It attacks the eyes, causing a copious flow of tears. It is made by the addition of bromine to acetone and has the composition $CH_2BrCOCH_3$. It is a colorless

liquid which boils at 126 deg. C., and has a specific gravity of 1.631 at 0 deg. C. It decomposes on standing. Bromoacetone is used in high-exposive shells and disseminated as a mist. See also Poison gases.

Bromobenzyl cyanide. A lachramatory poison used in chemical warfare. It is a solid of the composition $BrC_6H_4{\cdot}CH_2CN$, having a melting point of 29 deg. C., but when impure it is a liquid. It is prepared by chlorinating toluene, treating with sodium cyanide, and then brominating in sunlight. It is not purified, since it is easily decomposed. Bromobenzyl cyanide is thrown in high-explosive shells and disseminated as a mist. See also Poison gases.

Bronzalum. The trade name of an "anti-slip" metal made of bronze with abrasive grains cast in the metal. It is used for floor plates, stair treads, car steps, and door saddles. It is a product of the American Abrasive Metals Company.

Bronze. The general name for alloys of copper and tin. Bronze varies greatly in composition, and the alloys are marketed under a wide variety of names. Bronze may also contain some zinc or nickel. Manganese and silicon are also added for special purposes. In a true bronze tin is the predominating alloy metal with the copper, but some brasses are misnamed bronzes because of their color. Small amounts of zinc are claimed to give sharper castings free from blow holes. Small amounts of lead may also be added to bronze, chiefly to make them more free in cutting. Bronzes containing more than 90 per cent of copper are reddish, but below 90 per cent the color rapidly changes to orange-yellow. The ductility decreases with the increase in tin, and a bronze containing 15 per cent of tin cannot be forged. Bronze containing 95 per cent of copper and 5 of tin melts at 2,480 deg. F., while one containing 80 per cent copper and 20 of tin melts at 1,868 deg. F. Commercial bronzes may also contain small amounts of iron, arsenic, and other impurities. "Anti-acid bronze" contains a

high proportion of lead, and is used for valves and fittings. (See also Steam bronze.) Bronzes are employed widely for machine parts, ornaments, and various cast articles. Unlike zinc, the tin forms a chemical combination with the copper, and the crystalline structure thus formed is especially valued for machine bearings. Bronze is primarily a casting metal in contradistinction to brass, which is used mostly for drawing and rolling. See also Manganese bronze, Aluminum bronze, High-lead bronze, Gear bronze.

Bronze powder. Pulverized or powdered bronze or brass made by a hammering process. The color varies from yellow to reddish depending upon the proportions of copper and zinc. "Flitters" are made by reducing thin sheets to flakes, but are not as fine as bronze powder. A white bronze powder is made from aluminum bronze in the same manner. The powders are used as pigments and for bronzing. They should pass through a No. 100 screen, and from 3½ to 4 lb. to a gallon of varnish should make a free-flowing coat of paint.

Broom corn. A plant of the sorghum family, *Holcus sorghum*, grown in the Southwest, and in Illinois and Kansas, and used for making brushes and brooms. The jointed stems of the dwarf variety grown in the semi-arid regions are 12 to 24 in. long, and the standard brush corn is up to 30 in. long. The fibers are yellow in color, and when dry, coarse and hard. As a brush material they have the objection that they break easily, and are therefore unsuited for mechanical brushes for hard service. Broom root is similar to broom corn, but is from an entirely different plant, a grass, *Epicampes macroura*, of Mexico. The stems are also used for brushes.

Brush fibers. Industrial brushes are made from a wide variety of fibers, varying from the fine and soft camel's hair to the hard, coarse and brittle broom corn. Bristles from the hog form one of the most common, while the tampico and piassaba fibers are also important for polishing

brushes. Other fibers used are: Horsehair, from the manes and tails of horses, kittool, arenga, and istle, all from plants. Crin is from the leaves of a palm tree of Algeria. Vegetable and animal fibers are not resistant to alkalis and acids, and cannot be wetted with them. For such contact strands of steel, brass, bronze, or other metals are used for brush fibers.

Buckram. A coarse, plain-woven linen or cotton fabric heavily sized with gum or stiffening material. It is usually white or in plain light colors, and is employed as a stiffening material. It is also used sometimes as a serviceable cover for textbooks. The usual width is 24 inches.

Buffing compositions. The commercial compositions for buffing or polishing metal articles usually consist of dolomitic lime with from 18 to 25 per cent of saponifiable grease as a bond. The lime acts as an abrasive, and in some compositions is replaced in part by other abrasives such as emery flour, tripoli, pumice, amorphous silica, crocus, or rouge.

Building sand. Any variety of sand used for concrete other than pavements, or for mortar for laying brick and stone, and for plastering. Early specifications called for sand grains to be angular or sharp, but it is now recognized that better concrete or mortar can be made with rounded grains, because of the fewer voids in the mixture. Building sand is required to be clean, with not more than 3 per cent by weight of clay, loam, or organic matter as shown by a decantation test. The sand, according to the specifications of the American Society for Testing Materials, should meet the following requirements: All must pass through a $\frac{3}{8}$-in. sieve, 85 per cent through a No. 4 sieve, and not more than 30 per cent through a No. 50 sieve. For brick mortar all of the sand should pass through a $\frac{1}{4}$-in. sieve. For plaster, not more than 6 per cent by weight should be retained on a No. 8 sieve, and not more than 6 per cent should pass a No. 100 sieve. Flooring sand for mastic flooring is a clean sand passing through a No. 3 screen, 60

per cent through a No. 8, and about 7 per cent through a No. 100 screen. Roofing sand is a fine white sand.

Bull-dog. A name used in the trade for a mixture of ferric oxide and silica made by roasting tap cinder with free access of air. It is employed as a refractory lining for furnaces. Tap cinder is chemically a basic silicate of iron, $2FeO \cdot SiO_2$, which on roasting takes up oxygen.

Bulletwood. The name given to the wood of the balata tree, *Mimusops globosa*, of the Guianas, and to the gutta percha tree *Mimusops littoralis*, and other species, of Southern Asia. The wood has a deep red color, and a fine, open grain. It is extremely hard, and weighs 66 lb. per cu. ft. It is very durable, and is used in construction and in cabinet work. See also Balata.

Bunting. A light-weight, worsted fabric, plain-woven, and dyed in solid colors. It is employed mostly for making flags, for box lining, and other industrial uses. It was first made in the United States during the Civil War, coming previously from England. It wears well, and does not fade easily. Cotton bunting is a name given to a thin, soft, flimsy fabric of closer weave than cheesecloth. It is dyed in solid colors, and is used chiefly for cheap flags, decorations, and industrial uses. It fades easily.

Burlap. A very coarse, heavy cloth made of plain-woven jute, and widely used industrially for wrapping and bagging bulky articles. It is also used for upholstery linings, and for the backing fabric of linoleum. The best grades are also used for wall coverings. For bags and wrapping, the weave is apt to be coarser and irregular, and the color is natural or tan. Dundee, Scotland, is the largest center of burlap manufacture outside of India. Burlap is woven in widths up to 144 in., but 36, 40, and 50 in. are the usual widths.

Burnt alum. A name given to alum that has been calcined to drive off its water of crystallization. See Alum

Burrstone. A variety of chalcedony silica with a cellular texture. It is hard and tough stone, and occurs in white, gray, and cream color. Burrstone is used for millstones for grinding, and as a building stone. The best stones come from central France.

Burr-wood. Also called burr oak, or pollard oak. The wood of the decapitated European oak trees *Quercus pedunculata* and *Q. sessiliflora* of Great Britain. A "pollard" tree is one whose head has been cut off when the tree has reached a definite height. The growth in height of the main trunk is permanently arrested, and innumerable branches shoot out from the trunk. These produce humps, or "burrs," which cause the grain of the wood to run in all directions. Burr oak is valued for cabinet work. "Pollarding" of the trees is done for ornamental purposes.

Busheled iron. An inferior grade of iron or steel made by heating scrap iron and steel pieces together in a hearth furnace, and then forging and rolling them into bars. This metal is not uniform in quality, due to the mixture of various grades of metals, and because of the unreliability of the welding together.

Butternut. The wood of the butternut tree *Juglans cinerea.* It is hard and smooth, and resembles the wood of the black walnut very closely except for its color, which is yellowish-gray. Butternut has the same uses as black walnut, but the supply is limited.

Butyl alcohol. A colorless liquid used chiefly as a solvent for pyroxylin lacquers, molding compounds, paints and varnishes. There are four forms of this alcohol, but only the normal butyl alcohol is important commercially. Normal butyl alcohol has the composition $CH_3(CH)_3OH$, and is made by the fermentation of glycerol. It has a specific gravity of 0.814, and boils at 117 deg. Centigrade.

Cadalyte. A cadmium salt patented under U. S. patents 1,564,413 and 1,564,414, and used for cadmium plating of

screws, bolts, nuts, and machine parts where corrosion resistant properties are desired. It is dissolved in a bath of sodium cyanide and employed is a similar manner to other plating solutions. Cadmium anodes are used in this plating bath. The Cadalyte process is essentially the electro-deposition of cadmium on the articles. The coating is more resistant to corrosion than galvanizing or other coverings of zinc, and gives a silvery-white color similar to that of tin. The deposit is harder than tin, and takes a fine polish.

Cadmium. A silvery-white crystalline metal, symbol Cd. It is employed in soft solders with tin, lead, and zinc, and is also used for electro-plating in place of tin coatings for corrosion resistance. Cadmium resembles tin, and gives the same characteristic "cry" when bent. It occurs in the mineral greenockite, but is obtained chiefly as a by-product of the zinc industry. The largest production is in Tasmania. Cadmium has a specific gravity of 8.6, is very ductile, and can be readily rolled or beaten into very thin sheets. A small addition of zinc makes it brittle. It melts at 608 deg. F., and boils at 1,580 deg. F. The metal is marketed in small round sticks 12 in. long, packed in 100-lb. boxes. It is also sold in variously shaped anodes for electro-plating.

Cadmium amalgam. A silvery-white compound of cadmium and mercury, which softens on being moderately heated, and can be kneaded like wax. It is made by heating the mercury and introducing the cadmium in the form of thin sheet. Its composition is Cd_5Hg_8, and the excess of mercury separates out on standing. Cadmium amalgam remains soft for a considerable time, and finally becomes hard and crystalline. It is used for filling holes in metal where it is not desired to use heat. Tin or bismuth makes cadmium amalgam more pliable. Amalgams with an excess of cadmium are ductile, and can be hammered out into thin sheet. The amalgams do not tarnish easily.

Cadmium solder. A tin-lead solder containing cadmium, or a solder composed of lead and cadmium, the latter replacing the tin. A solder containing 80 per cent of lead, 10 of tin, and 10 of cadmium has about the same strength as a 50–50 tin-lead solder, and has greater ductility. It is, however, darker in color due to the greater proportion of lead. Cadmium solders may contain as much as 90 per cent of lead with 5 per cent of tin, and 5 of cadmium, or 10 per cent of cadmium without the tin. Cadmium solders are hard, have low melting points, and are usually cheaper in price than tin solders. They have the same uses as tin-lead solders.

Cadmium sulphide. A yellow powder of the composition CdS, used as a pigment. It is a brilliant permanent color, and is valued for either oil or water paints. It is also called cadmium yellow.

Caesium. A rare elementary metal, symbol Cs. It is the most electropositive of all the elements. It resembles rubidium and potassium in appearance, being silvery-white and soft. It oxidizes easily in the air, and decomposes water. The specific gravity is 1.88, and the melting point is 26 deg. C. The chief source of the metal is the mineral pollucite, but it also occurs in lepidolite, and in petalite. Due to its rarity it has not yet found commercial application in alloys, but it is used on the filaments of detector and amplifier tubes to increase the sensitivity of radio detection. The caesium is introduced in the form of caesium chloride and interacts with the thorium of the filament to produce positive ions.

Cal. The trade name of a hydrated lime product used for waterproofing and accelerating the set of portland cement concretes. About 5 lb. is mixed dry with each bag of cement. It is a product of the Security Cement and Lime Company, Hagerstown, Md., and its Spanish name means lime.

Calamine. An ore of the metal zinc, found in New Jersey, Pennsylvania, Virginia, Missouri, and in various places

in Europe. Calamine was formerly mixed directly with copper in the furnace in making brass, but the ore usually contains less than 3 per cent of zinc, and is concentrated to from 35 to 45 per cent and then roasted and distilled. Calamine is a silicate of zinc, $H_2(Zn_2O)SiO_4$. It is a mineral occurring in crystal groups of a vitreous luster, and may be white, greenish, yellow, or brown in color. The hardness is 4.5 to 5, and the specific gravity is 3.4. It occurs often with smithsonite, another zinc ore.

Calaverite. An ore of gold. It is a gold telluride, $AuTe_2$, containing 44 per cent of gold, and found with sylvanite in Colorado, California, and West Australia. Its structure is usually granular, with a metallic luster, a silvery-white color with gray streaks, and a specific gravity of 9.35. Its hardness is 2.5. It is easily fusible.

Calcinite. The trade name of a silicon carbide made in the electric furnace and used as an abrasive. It is a product of the Pittsburgh Grinding Wheel Company. See Silicon carbide.

Calcite. One of the most common and widely diffused minerals, and used for the making of lime for mortars and cements. It also includes the limestones used extensively as building stones. Calcite occurs in the form of limestones, marbles, chalks, calcareous marls, and calcareous sandstones. It is a calcium carbonate, $CaCO_3$. Its specific gravity is 2.72, and hardness 3. It is usually white or colorless, or tinted with impurities. When limestone is heated to about 1,000 deg. F. it loses its carbonic acid, and is converted into quicklime, CaO. See Lime, Chalk, Marble.

Calcium. A metallic element, symbol Ca, which belongs to the group known as alkaline earths. It is one of the most abundant substances, and occurs in limestones and other minerals. It is obtained in metallic form by electrolysis, but owing to its unstable nature is not used in its pure state. The silicide is employed as a deoxidizer in melting steel, copper, and some other metals. See Dolomite. Calcium

has also been used as an alloying material for hardening soft metal alloys. It is light-yellow in color. When heated in the air it burns with a brilliant white light. The specific gravity is 1.55. Many compounds of calcium are used industrially.

Calcium carbide. A hard, crystalline substance of a grayish-black color, used widely for the production of acetylene gas for welding torches and lighting. It was discovered in 1892, and is made in the electric furnace by reducing lime with coke. The specific gravity is 2.26. Its composition is CaC_2, containing theoretically 37.5 per cent of carbon. When water is added to calcium carbide, acetylene is formed, leaving a residue of slaked lime. Chemically pure carbide will yield 5.83 cu. ft. of acetylene per lb. of carbide. The commercial carbide is usually guaranteed to yield 5 cu. feet.

Calcium chloride. A white, crystalline, lumpy substance of the composition $CaCl_2$, employed for fire-proofing paints, for "curing" and accelerating the setting of concrete, and for spreading on gravel or macadam roads to aid in surfacing. The specific gravity is 2.152. It is soluble in water, and is highly hygroscopic and deliquescent, which causes it to retain enough moisture to act as a stabilizer on roads. The commercial product usually contains only about 75 per cent of $CaCl_2$, with the balance impurities and water. Calcium chloride was formerly much used as an antifreeze mixture for automobile radiators, but was found to corrode the metals badly.

Calcium-silicon. An alloy of calcium and silicon used as a deoxidizing agent, and for the elimination of sulphur in the production of high-grade steels. It is marketed by one of the important producers as "low-iron," containing 22 to 28 per cent of calcium, 65 to 70 per cent of silicon, and a maximum of 5 per cent of iron; and as "high-iron," containing 18 to 22 per cent of calcium, 58 to 60 of silicon, and 15 to 20 of iron. It comes in crushed form, and is added to the molten steel.

Calido. The trade name of a heat-resistant alloy containing 59 per cent of nickel, 16 of chromium, and the balance iron. It is a product of the Driver-Harris Company, and is used chiefly as resistance wire in electrical heating apparatus. The melting point is 1,400 deg. C. It will resist oxidation at temperatures up to 900 deg. C. The tensile strength when soft is 90,000 lb. per sq. in. It is marketed in the forms of wire and ribbon in standard gage sizes.

Calite. The trade name of an iron-nickel alloy of the class known as heat-resistant alloys. It is made in various grades and resists oxidation when subjected in continuous heating up to 2,000 deg. F. A typical Calite contains 35 per cent of nickel, 5 of chromium, 50 of iron, and 10 of aluminum. It has a melting point of 2,775 deg. F. Its tensile strength is 56,800 lb. per sq. in., and the specific gravity is 7.03. Calite is cast easily, and is used chiefly for boxes for heat-treating purposes. It cannot be machined, nor cut with the gas flame. It is a product of The Calorizing Company, Pittsburgh.

Calorene. The trade name of a gas obtained by breaking down ethyl alcohol. It is marketed in steel cylinders under high pressure, and is used chiefly for flame cutting torches. Calorene consists mostly of ethylene, C_2H_4, and gives a low-temperature flame when burned with oxygen.

Calorite. The trade name of a heat-resistant alloy containing 65 per cent of nickel, 12 of chromium, 15 of iron, and 8 of manganese. It is used for resistance wires in electrical heating apparatus.

Cameline oil. Also called dodder oil, or German sesame oil. A light-yellow oil having a peculiar pungent odor, and used as an adulterant of rapeseed oil, which is employed in quenching baths and in lubricants. It is obtained from the German plant *Camelina sativa,* the seeds yielding 35 per cent of the oil. It contains oleic, linolic, and palmitic acids, and also erucic acid, which is characteristic of rapeseed oil.

Camel's hair. The fine, wooly hair from the neck and back of the camel, employed industrially for fine brushes for painting. Most of the fiber comes from Arabia and Persia, and the bulk of it goes into the weaving of fabrics. The natural color is light-brown, and the finer grades of underhair are soft and silky. The fine hairs are about 1 in. long, but the coarser top hairs are up to 4 in. in length. These constitute the grades used for brushes.

Camphor. The peculiar white resin of the *Cinnamomum camphora*, an evergreen tree with laurel-like leaves, and reaching a height of 100 ft. Camphor is used in celluloid manufacture, disinfectants, and in explosives, and the oils of camphor are used as turpentine substitutes. More than 80 per cent of the camphor production is employed for celluloid, 15 per cent for disinfectants, and the remainder for a great variety of uses. The tree occurs naturally in China, and Southern Japan. Formosa is the center of the industry. Camphor, $C_{10}H_{16}O$, is contained in all parts of the tree, but in Formosa it is distilled almost exclusively from the wood of the trunks, roots, and large branches. Steam or water distillation is employed, and from 20 to 40 lb. of chips produce 1 lb. of camphor. The crude camphor is refined principally in Kobe, and the crystallized "flowers of camphor" is pressed to remove the oil. Camphor has a specific gravity of 0.986 to 0.996, and melts at 175 deg. C. The red, or raw, camphor oil is fractionated into white and brown camphor oil, the first of which is used as a turpentine substitute, the brown oil going into cheap perfumery making. Synthetic camphor is derived from turpentine, borneol, or other substances by complex processes. Commercial synthetic camphor is optically inactive, and usually contains some impurities. See also Borneol, and Lindol.

Camwood. The wood of the tree *Baphia nitida*, native to West Africa. The wood has been used in England for machine bearings, and is claimed to withstand bearing pressures up to 8,000 lb. per sq. in. It is also used for tool handles. It is exceedingly hard and has a coarse, dense

grain. The weight is about 65 lb. per cu. ft. This wood is sometimes confused with barwood, employed for the same purposes. Camwood is also used as a dyewood, and has a reddish-brown color.

Canada balsam. Also called balm of Gilead. A yellowish, viscid liquid of pleasant odor and bitter taste, obtained from the pine tree *Abies balsamea*, of the Northeastern States and Canada. It is a class of turpentine, and is used as a solvent for paints, and in polishes and leather dressings. When distilled it yields turpentine, and leaves rosin as a residue.

Canary whitewood. Also called whitewood, or tulipwood. The wood of the tree *Liriodendron tulipifera*, of the eastern United States and Canada. The tree has large, tulip-like flowers. The wood is widely known as poplar in the trade, and is used for carpentry, and for many articles where a close, even grain is desired. Due to its close texture and even coefficient of expansion it is used for expansion blocks in humidity regulators and testers. The color of the wood is yellowish, the weight is about 30 lb. per cu. ft., and it is quite soft.

Candelilla wax. A secretion found on all parts of the candelilla plant, growing abundantly in northern Mexico and in the southwestern United States. It is obtained by boiling the plant in water, and skimming off the wax. Candelilla wax is used for varnishes, lacquers, polishes, and for insulating material. It is also used as a substitute for carnauba wax, and to adulterate beeswax. The specific gravity is 0.983, and the melting point is 67 deg. Centigrade.

Candle-nut oil. An oil obtained from the kernels of the fruit of the *Aleurites moluccana*, a tree found in Oceania, the West Indies, and South America. The oil is variously known as kukui, kekune, walnut, lumbang, and artists' oil, and is used as a drying oil for paints. The specific gravity is 0.923, and the iodine value is about 185. The fruit resembles the walnut, but has a thicker shell. The

kernels contain up to 70 per cent of oil, which is extracted by pressing. The oil contains 57 per cent of oleic and 33 per cent of linolic acids.

Cannel coal. A variety of coal differing from ordinary coal in properties and composition. It is close and compact in texture, dull black in color, and breaks along joints, often appearing like black shale. It burns with a long, luminous, smoky flame, from which characteristic it derives its old English name, meaning candle. On distillation cannel coal yields a large proportion of highly illuminating gas, up to 16,000 cu. ft. per ton, leaving a residue consisting mostly of ash. At low temperature it yields a high percentage of tar oils. The proportion of volatile matter may be as high as 70 per cent. Cannel coal consists of coaly matter intimately mixed with clay or shale, often containing fossil fishes. It is supposed to have been derived from vegetable matter in lakes. It is found in Great Britain, and in the United States in Kentucky, Ohio, and Indiana. It is chiefly valued for its quick-firing qualities.

Canvas. A general name for a dense, heavy cloth of plain weave used for sails, sacks, packing, tents, and in other places where strength and durability are needed. It was formerly made of hemp or unbleached flax, but is now made of cotton. Canvas may be of many grades and qualities of fine to coarse yarns and weaves, and it may be soft finished or highly sized. See also Duck.

Caoba. The Spanish name for mahogany frequently applied in the lumber trade to the mahogany woods from the West Indies and tropical America. See Mahogany.

Carbobrant. The trade name of an artificial silicon carbide used as an abrasive. It is a product of the Brantford Grinding Wheel Co., Ltd., Brantford, Ontario. See Silicon Carbide.

Carbofrax. The trade name of a refractory cement employed for furnace linings and fire brick. It is essentially

a silicon carbide with a small amount of binder material, and it will withstand temperatures above 3,000 deg. F. It is a product of The Carborundum Company, Perth Amboy, N. J., and is marketed in four grades. Carbofrax cement No. 4, the highest grade, vitrifies at 2,460 deg. F., and will not fuse under 3,300 deg. F. The tensile strength at 2,550 deg. F., is 1,750 lb. per sq. inch.

Carbolite. The trade name of an artificial silicon carbide made in the electric furnace, and used as an abrasive. It is a product of the American Emery Wheel Works, Providence, R. I. See Silicon carbide.

Carbolox. An artificial abrasive made in the electric furnace. It is a silicon carbide, and is a product of the Dominion Abrasive Wheel Co., Mimico, Ontario. See Silicon carbide.

Carboloy. The trade name of a cutting metal used for tools for machining hard metals. It is made up of tungsten carbide bonded together with cobalt which has been diffused through the finely granular carbide by pressure. It will cut at higher temperatures and greater speeds than high-speed steels. Carboloy has a hardness of about 2,000 Brinell, and a modulus of rupture in cross-bending of 275,000 lb. per sq. in. It will withstand severe blows. It is a product of the Carboloy Company, Inc., Schenectady, New York.

Carbon. The most widely diffused of all elements. It occurs in many combinations, and in many different forms. It is colorless and transparent as in the diamond, opaque and black in graphite, porous and velvety as in charcoal. It enters largely into coal, and is present in combination in gases, minerals, and organic materials. The symbol is C. The specific gravity is from 1.9 to 3.52. Amorphous carbon is not soluble in any known solvent. It is infusible, and is chemically inactive at ordinary temperatures. At high temperatures it burns and absorbs oxygen. It has the property of dissolving in some molten metals, notably iron,

and exerting great influence upon them. Cast iron, with graphitic carbon, and steel, with combined carbon are examples of this. The carbon atom has the peculiar property of forming "ring" compounds, and there are ten times as many compounds of carbon as of all other known compounds of all other elements. Carbon enters into all organic material, and has the widest use of any element. "Carbon" brushes and electrodes are made of carbon in the form of graphite, petroleum coke, lampblack, or other material, sometimes mixed with copper powder to increase the conductivity, and then pressed into blocks and baked. See also Graphite, Diamond, Charcoal, Carbon black, Lampblack.

Carbon bisulphide. A liquid of the composition CS_2, made by heating together carbon and sulphur. It is inflammable and poisonous, and dangerous to handle, but is a valuable solvent for oils, fats, waxes, and resins. It has a specific gravity of 1.263, boiling point of 46 deg. C., and solidifying point of −113 deg. C. The liquid is highly refractive, and has a characteristic smell.

Carbon black. The carbon resulting from the incomplete combustion of a gas, deposited by contact of the flame on a metallic surface. Carbon black from artificial gas is a very glossy product with an intense color. Most of the commercial product is from natural gas. Carbon black is used as a paint pigment, in stove polishes, carbon paper, typewriter ribbons, crayons, and printing and drawing inks. It is also employed in automobile tires to give wearing qualities to the rubber, 10 per cent of the weight of the tire being carbon black. The American production of carbon black is 200,000,000 lb. annually, of which nearly 50 per cent goes into tires. Louisiana is the largest producer. The yield per thousand cubic feet of gas is from 1.1 to 1.8 pounds.

Carbonite. A natural coke found in England and in Virginia. It is a coke-like mineral formed by the baking action of igneous rocks on seams of bituminous coal. It is

used as a coke. The name is also used as a trade name for an activated charcoal made from a mixture of finely ground anthracite, pitch, and sulphur. See Activated charcoal.

Carbon paper. Paper used for duplicating pen, pencil, or type writing. It is made by coating the paper with a mixture of a pigment and a medium. The pigments used include carbon black, Prussian blue, organic red, and blue and green lakes. The medium is composed of mixtures of waxes and oils chosen to give a composition of the desired consistency and melting point. The waxes and oils may be carnauba wax, paraffin, castor oil, oleic acid, stearic acid, or pitch. Paper of a special texture must be used, and rag papers are considered the best.

Carbon steel. The name given to a class of steel owing its distinctive properties chiefly to carbon chemically combined with the iron. If other elements in influencing proportions are combined in the steel the latter is then designated as an alloy steel, regardless of the carbon content. Carbon steels containing more than 0.60 per cent of carbon are usually classed as tool steels. Those containing below 0.20 per cent are usually called iron, while the intervening range is known as soft steel or machinery steel. There is, however, no fixed dividing line. Carbon steels have a wide range of uses for construction, machinery, and tools. A cold-drawn steel or rolled steel containing 0.20 per cent of carbon may have a tensile strength of 40,000 to 60,000 lb per sq. in., and an elongation of 30 to 40 per cent in 2 in. while one having 0.40 to 0.50 per cent of carbon may have a strength of 120,000 lb. per sq. in. See also Tool steel Machinery steel, Alloy steel, Iron, Steel, Ingot iron.

Carbon tetrachloride. A light, colorless liquid of the composition CCl_4, which is an important solvent for asphalt rubber, bitumens, and many gums. It is also employed as a cleaning agent, and is used in such cleansing compound as "Carbona." Another use is as a fire extinguisher and it is a component of chemical extinguishers such a

"Pyrene." It is also used as an antiseptic and disinfectant. Carbon tetrachloride is obtained by the chlorination of carbon bisulphide in the presence of sulphur chloride. The specific gravity is 1.583. It boils at 77 deg. C., and solidifies at −25 deg. Centigrade.

Carbora. An artificial silicon carbide used as an abrasive. It is a product of the Cortland Grinding Wheel Corporation, Chester, Mass. See Silicon carbide.

Carborite. The trade name of a silicon carbide made in the electric furnace, and employed as an abrasive. It is a product of the Vitrified Wheel Company, Westfield, Mass. See Silicon carbide.

Carborundum. The trade name for a silicon carbide employed as an abrasive and as a refractory. It is a product of the Carborundum Company, Niagara Falls, N. Y. See Silicon carbide.

Carmine lake. A brilliant red pigment used widely as a color in various industries and in paints. It is made by precipitating a mixture of cochineal and alum by the addition of acid oxalate or potassium tartrate. It is sometimes likely to be adulterated with starch, kaolin, red-lead, or chrome red.

Carnauba wax. An exudation from the leaves of the palm tree *Copernica cerifera*, of Brazil. It comes in hard, vitreous, yellowish lumps that melt at a temperature of about 85 deg. C., and have a specific gravity of 0.995. It is insoluble in water, but soluble in alcohol and in alkalies. Carnauba wax is used in varnishes, floor polishes, leather dressings, and for adulterating beeswax. It increases the hardness of beeswax or paraffin.

Carnotite. A mineral found in Utah and Colorado mixed with porous sands, and employed as a source of radium. Carnotite is a vanadiate of uranium and potassium, $V_2O_5 \cdot 2VO_3 \cdot KO \cdot 3H_2O$. It has a yellow color, and gives the sands a pale-yellow tint. The sands occur in immense beds.

They are treated with hydrochloric acid, which dissolves the carnotite, and then with sulphuric acid which precipitates the barytes and carries out the radium as radium sulphate. This is further treated, converting it to carbonates and to chlorides and bromides. Only one gram of radium is obtained from the treatment of 400 tons of carnotite sands. See Radium.

Carpenter stainless steels. The proprietary name for a group of high-chromium, corrosion- and heat-resisting steels made by The Carpenter Steel Company, Reading, Pa. There are five grades as follows: No. 1, containing 0.10 per cent of carbon, 0.40 of manganese, 0.30 of silicon, and 13.0 of chromium; No. 2, containing 0.30 per cent of carbon, 0.40 of manganese, 0.30 of silicon, and 13.0 of chromium; No. 3, containing 0.30 per cent of carbon, 0.40 of manganese, 0.30 of silicon, 20 of chromium, and 1.0 of copper; No. 4, containing 0.12 per cent of carbon, 0.40 of manganese, 0.30 of silicon, 18.0 of chromium, and 9.0 of nickel; and No. 5, containing 0.10 per cent of carbon, 0.40 of manganese, 0.40 of silicon, and 14.0 of chromium. It is claimed that from these five grades may be selected a steel to resist almost any corrosive condition except pure hydrochloric or hydrofluoric acids, and to resist oxidation at any temperature up to 2,200 deg. F. No. 5 is a special free-machining grade for automatic screw machine work. The other grades range from soft deep-drawing quality up to a hard spring temper. No. 4 is non-magnetic. See also Stainless steel.

Cartridge brass. One of the standard brass alloys of the brass mills. It contains 70 per cent of copper and 30 per cent of zinc. The highest grade of zinc is used, care being taken to exclude any lead. It has high ductility, and is especially adapted for drawing operations. It derives its name from its use in making deep-drawn cartridge shells. It is also employed for spinning.

Case-hardening materials. Any materials employed for adding carbon to the outside of low-carbon steels or to iron

so that upon quenching a hardened case is obtained. The usual solid material for this purpose is charcoal made from bone or wood. It is obtained in "compound" form mixed with barium carbonate, charred leather, coal, or coke. The articles to be "carburized" for case hardening are packed in the compound in metallic boxes for heating in the furnace. The principal liquid carburizing material is sodium cyanide, which is melted in a pot and the articles dipped in, or rubbed on the red hot steel. Gases, rich in carbon, such as methane, may also be used for carburizing, by passing the gas through the box in the furnace. Case-hardening compounds are marketed under a wide variety of trade names, and many have a base of hardwood charcoal or of charred bone, with chemicals such as sodium carbonate, barium carbonate, or calcium carbonate. Case-hardening by packing in compounds, is called "pack-hardening." Cyanide hardening gives an extremely hard, but superficial case. It is valued for instruments.

Casein. A white to yellowish substance found in milk, and employed in making molding materials, imitation ivory and amber, glazing for paper, glues, leather dressings, polishes, and for a variety of other uses. It is marketed as a granular powder or in small lumps, and is produced as a by-product of the butter and cheese industries. Cow's milk contains about 3 per cent of casein. The skim milk is treated with acid to precipitate out the casein. Argentina is the greatest producer and exporter of the material. Casein is insoluble in water or in alcohol, but it attacked by alkalies.

Casein resin. A group of substances used as molding materials for the manufacture of many commercial articles. They are known under various trade names, such as Inda, Aladdinite. In general the molding material is made by the action of formaldehyde and rennet casein. Calcium chloride or some other hygroscopic salt is used also to prevent the resin from becoming rubbery. Albumen and natural salts are removed when a transparent product is

required. Casein resins, also called casein plastics, can be molded under pressure and heat to almost any shape. They are non-inflammable and good electric insulators. They can be dyed to any color. Unlike the phenol resins they can be machined easily, but are not as hard and durable, and are therefore not as suitable for mechanical and electrical parts.

Cassiterite. Also called tin stone. It is the only commercial ore of tin, and is a tin dioxide, SnO_2, containing 78.6 per cent of tin. It usually occurs massive granular with a specific gravity of 6.8 to 7.1, and a hardness of 6 to 7. The color is usually brown or black with a dull luster. Cassiterite is a widely distributed mineral, but is found on a commercial scale in only a few localities. It is worked in Cornwall, England, in Bolivia, Malay Straits, and in parts of Australia. The mineral cassiterite is present in the ore usually in amounts of from 1 to 5 per cent. It occurs in veins, called "lode tin," and in placer deposits. Lode tin is first crushed, and then concentrated by gravity. It is roasted to eliminate sulphur and arsenic. The concentrates average 65 to 70 per cent. The smelting is done usually in reverberatory furnaces. See also Tin.

Cast iron. A combination of pure iron with from 2 to 6 per cent of carbon, receiving its name from the fact that it is readily cast into almost any desired shape. Cast iron is of two kinds, white cast iron, and gray cast iron. The first is a chemical compound of iron with the carbon, while the second contains most of the carbon in the state of graphite mechanically mixed with the iron. Cast iron is brittle and not malleable. Its advantages are that it is easy to give it any desirable form in the casting, and it is easy to machine. It is also the cheapest metal. It is used for the intricate and massive parts of machinery. White iron is made by chilling gray cast iron, and may be converted into gray iron by heating to 1,850 deg. F. for several hours. Nickel chromium, and other metals are sometimes added to cast iron while molten in order to give it additional strength

toughness, or hardness. Cast iron is made by melting pig iron in a cupola in contact with the fuel, which is usually coke. The pouring temperature is about 2,460 deg. F. Silicon and sulphur are impurities in cast iron that injure it if present in large amounts. Silicon makes the iron glassy hard, but is occasionally added for special castings. Phosphorus is beneficial in quantities less than 0.6 per cent, but makes it hard when present in larger amounts. "Synthetic cast iron" is made from steel scrap and turnings melted together with carbon in the electric furnace. See also Malleable iron, Semi-steel, Nickel cast iron, High-test cast iron, and Nomag.

Castor oil. An oil obtained by expression from the seed beans of the castor plant, *Ricinus communis*, which grows wild, and is also extensively cultivated in nearly all tropical and sub-tropical countries. During the European war it was used as an airplane engine oil. It is now used for mixing with other oils for cutting compounds and for some lubricating oils. It is also converted into blown oils. Another commercial use is as a medium in gums and in such things as carbon paper pigments. The castor oil seeds have the appearance of mottled colored beans, and are enclosed in hard husks which are removed before crushing. The beans contain about 50 per cent of oil. The oil obtained from the first cold pressing is used largely in medicine as a powerful purgative. The inferior grades from the second and third hot pressing are the commercial lubricating oils. The residue cake is poisonous, and is used only as a fertilizer. Castor oil consists largely of the glyceride of ricinoleic acid, and when pure is colorless and transparent. It has a characteristic acrid, unpleasant taste. The iodine value is 82 to 90, and the saponification value is 147. The specific gravity is about 0.965. It is soluble in alcohol.

Cast steel. Steel that has been cast into sand molds to form finished or semi-finished machine parts or other articles. Steel castings are used to replace forgings where only small

quantities are required that would not justify the cost of forging dies. Cast steel is stronger and tougher than malleable iron, and when properly heat-treated will have a tensile strength above 70,000 lb. per sq. in. The carbon content of cast steel is not usually over 0.45 per cent, and the manganese is usually 0.60 to 0.80 per cent. Nickel, chromium, or a high percentage of manganese may be added to make special alloy castings, but the term "cast steel" generally refers only to plain carbon steels. The shrinkage allowed for cast steel is ¼ in. per ft. Cast steel has the disadvantage in comparison with forged steel that it may contain blow holes, slag, sand holes, shrinkage cavities, or "cold shuts," the latter from pouring at too low a temperature.

Cataract metal. A trade name of an alloy of copper and nickel with smaller amounts of various other elements. It is a product of the Niagara Falls Smelting & Refining Corporation. It is silvery-white in color, and is highly resistant to corrosion and to the action of most acids. The tensile strength reaches 55,000 lb. per sq. in. Its melting point is between 2,250 and 2,350 deg. F., depending upon its composition. It is ductile and malleable, casts easily, and is easily machined. It is employed for machine parts that are required to resist acids or corrosive influences.

Catechu. An extract obtained from the heart-wood and from the seed pods of the tree *Acacia catechu*, of Japan and Southern Asia. It is used in tanning leather, and also as a dyestuff, giving a brown color. The name, meaning in Japanese "tree juice," is also sometimes erroneously applied to gambier, which also contains catechu tannin, $C_{15}H_9(OH)_5$. Catechu, or "cutch," comes either as a liquid which is a water solution, or as brownish, brittle, glossy cakes. The extract contains 25 per cent of tannin, and the solid 50 per cent. It is a powerful astringent. Burma cutch is from *Acacia catechuoides*. Indian cutch is from *Acacia sundra*. The latter is frequently adulterated with starch, sand, or other materials.

Catgut. String made from the intestines of sheep, used chiefly for violin strings, but also for tough, durable cords for making racquets and a variety of other articles. After cleansing and soaking in an alkali solution, the intestines are split, drawn through holes in a plate, cured in sulphur or other substance, and graded according to size.

Caustic soda. The common name in commerce for sodium hydroxide, used for cleansing and bleaching. See Sodium hydroxide.

Cedar. A very general name which includes a great variety of woods. The true cedars comprise trees of the natural order *Coniferae*, genus *Cedrus*, of which there are three species: Lebanon cedar, *Cedrus libani*, Himalayan cedar, *C. deodora;* and Atlas cedar, *C. atlantica*. The differences are slight, and all of the species are sometimes classed as *Cedrus libani*. All are mountain trees, and are native to Europe, Asia, and Africa. The woods of the three trees are almost indistinguishable. Cedar is yellow in color, takes a beautiful polish, and is very durable. It is also very fragrant. It is used in construction work, and timbers in temples in India more than 400 years old are still in perfect preservation. The wood weighs about 36 lb. per cu. ft. Numerous species of *Cedrela* occur in tropical America, Asia, and Africa, and are also commonly called cedar, but the wood resembles mahogany. See Spanish Cedar and Paraguayan cedar. "Pencil cedar" is the wood of several species of juniper trees. See Pencil cedar. In the United States and Canada the name cedar is also applied to woods of species of *Thuya*, *Juniperus*, and *Cupressus*. See Yellow cedar, Western white cedar, Port Orford cedar, and Canadian juniper.

Celite. The trade name of a natural silica material employed for firebricks and furnace linings. It is a compact deposit from ancient shells, and is cut into bricks for marketing. Celite will withstand temperatures up to 1,600 deg. F. It is mined in California, and is a

product of the Celite Products Company, N. Y. See also Sil-O-Cel.

Cellophane. The trade name of a thin, transparent, flexible material made from nitro-cellulose, and employed in the form of sheets for wrapping various products. It is usually made colorless, but for fancy packages it is made in light shades of red, green, amber, or other colors. It is a product of the E. I. du Pont de Nemours & Co., Inc.

Celluloid. A compound consisting of nitro-cellulose treated with camphor to reduce its inflammability and make it more plastic. It has a wide variety of uses as a molding material. Celluloid was invented in 1870 by J. W. and J. S. Hyatt, U. S. patent 105,338. It is now made from nitrated cotton, the proportion of nitrogen being from 9.5 to 11 per cent, and the compound is not detonated by a blow. See Nitro-cellulose. It usually contains 30 to 40 parts of camphor for 100 parts of nitro-cellulose. Methyl or amyl alcohols are the usual solvents. The coloring matter is added during the incorporating of the camphor, or by external application. Gold and silver are put on in a solution of collodion. Mottling is described in U. S. patents 460,086 and 749,297. Celluloid is a transparent mass, molding easily at 100 deg. C. It is highly elastic, and has high tensile strength. It is insoluble in water, but is soluble in alcohol, and is decomposed by various acids. It can be cemented with dichlorohydrin. At 145 deg. C. it begins to decompose, and when ignited it burns with a smoky flame. The fumes are extremely poisonous, and affect the heart. Stannous chloride, or some other substance, is sometimes employed in celluloid to make it "uninflammable." Modified celluloids, without camphor, are made by substituting methyl-acetanilide or other chemicals. Ordinary celluloid weighs about 0.050 lb. per cu. inch.

Cellulose acetate. An amber colored, transparent mass, of the composition $C_6H_5(CO_2CH_3)_5$, employed as a molding

compound, and for making artificial silk, or "rayon," and for photographic films, and lacquers. It is made by the acetylization of cellulose with acetic acid. Unlike nitrocellulose, or pyroxylin, it is not inflammable, and also does not discolor like pyroxylin. For this latter reason and because of its lighter color it is preferred to pyroxylin for making the triplex non-shatterable glass. As a plastic molding material it can be formed in molds at 2,000 lb. per sq. in. pressure to any desired shape. The parts can be machined easily, are tough, and not brittle. The molding material is used for making electrical parts, buttons, handles, toilet articles, and other things. It is insoluble in water or in oils, but soluble in alcohol. The lacquers are solutions in organic solvents, are quick drying, and can be made to any color with suitable pigments. They are used for automobile finishes, and for general ornamental painting.

Celotex. The trade name of a fiber board made from bagasse, or the refuse from the crushing of sugar cane, and employed as a covering material for walls for insulating purposes, or for building partitions. It is claimed to be an excellent sound insulator. It is a product of the Celotex Company, Chicago, and is marketed in sheets of various thicknesses and sizes.

Cement. A substance, generally in powdered form, that can be made into a paste usually by the addition of water, and when molded will set into a solid mass. Cements are extensively used for building construction, the best known being portland cement for making concrete. See Portland cement, Roman cement, Keene's cement, Gypsum, Plaster of Paris, Scott's cement. Natural cements are produced by the burning of sandy limestones and grinding the product. They contain less lime and are inferior to portland cement. Various trade names are given to these cements. Oxychloride cement is composed of magnésium chloride and calcined magnesia. It is used for floors and stucco. Numerous organic and inorganic compounds used for fastening together, or "cementing," materials are called

cements. These include glues (See Glue), and also mixtures of rubber or other gums which have been dissolved in carbon bisulphide and compounded with linseed or other oils. See also Lumnite cement, Hydraulic lime.

Cement mortar. A mixture of portland cement, sand, and water. Cement mortar is much harder and more durable than lime mortars, but some lime is often added to make it spread more readily. The proportion of sand is not greater than 3 to 1 of cement. Cement mortar is more costly than common mortar, but is useful in masonry exposed to running water or sea water, or where great strength is required. It is also employed as a finish covering for walls of masonry, brick, or concrete. A 2½-to-1 cement mortar weighs about 135 lb. per cu. foot.

Cerargyrite. An ore of the metal silver, found in the upper zone of silver veins. It occurs in Nevada, Colorado, Idaho, and in Peru, Chile, and Mexico. It is sometimes called horn silver due to its horn-like appearance. It is a silver chloride, AgCl, containing theoretically 75.3 per cent of silver, with sometimes some mercury. The hardness is 2.3, and specific gravity is 5.8. It is usually massive, resembling wax, with a pearl-gray color.

Cerium. A metallic element, symbol Ce, belonging to the rare-earth group of metals. It is not used alone, but has a variety of uses in its compounds. Cerium has an iron-gray color, is only slightly harder than lead, and is malleable. It melts at 623 deg. C. The specific gravity is 6.92. The chief source of cerium is monazite sand from Brazil, India, and the Carolinas, but it is a by-product of the incandescent mantle industry, left in the residue of the sand after the thorium oxide is removed. The monazite contains from 25 to 35 per cent of cerium oxide. Cerium nitrate is used in gas mantle manufacture. The cerium mixed metal, known as "misch metal," is employed with iron in making pyrophoric alloys. Cerium salts are used for dyes and in coloring glass. See Auer metal, and Misch metal.

Cerussite. An important ore of the metal lead. It is a lead carbonate, $PbCO_3$, found widely distributed. The mineral is of secondary origin, formed by the oxidation of galena in the presence of carbonated waters. It occurs in crystals or in granular crystalline aggregate or massive. Its color is white to gray, and it is transparent to opaque. The hardness is 3 to 3.5, and the specific gravity is 6.55. It is easily fusible. See Galena.

Chalcocite. An important ore of copper. It occurs in large quantities in Montana, and with other minerals in Alaska, Chile, Peru, Mexico, and Bolivia. It is a cuprous sulphide, Cu_2S, containing theoretically 79.8 per cent of copper. It usually occurs massive, but crystals are also found. Its hardness is 2.5 to 3, and the specific gravity is 5.5. It has a shining, lead-gray color.

Chalcopyrite. The most important ore of copper. Also known as copper pyrites, and yellow copper ore. It occurs widely distributed associated with other minerals, and may carry gold or silver. It is the chief ore of the copper mines n England, Sweden, Spain, Canada, South Africa, Chile, and many parts of the United States. Chalcopyrite is a sulphide of copper and iron, $CuFeS_2$, containing theoretically 34.5 per cent of copper, and 30.5 per cent of iron. It usually occurs massive, with a hardness of 3.5, and a specific gravity of about 4.2. The color is brass-yellow, with greenish-black streaks. To obtain the copper the ore is first smelted to matte instead of to the metal. This matte is a mixture of Cu_2S and FeS, together with impurities. Enough sulphur s supplied in melting to combine with all of the copper. Smelting is usually done in blast furnaces with a weaker educing action than an iron furnace. The matte is then oured into a reverberatory furnace where air is blown hrough, converting the iron to iron oxide, and the sulphur o sulphur dioxide. No fuel is used. When the sulphur is one the copper is cast into pigs, which are called "blister opper," due to the blistered appearance caused by the ulphur dioxide escaping.

Chalk. A fine grained limestone, or soft, earthy form of calcium carbonate, CaO and CaO_2, composed of finely pulverized marine shells. It has a very wide variety of industrial uses. Whiting and Paris white are names given to grades of chalk that have been ground and washed. Chalk is employed in putty, crayons, paints, rubber goods, linoleum, calcimine, and metal polishes. Chalk comes largely from the southern coast of England and the north of France. The color is white, gray, or yellowish, depending on the impurities. The specific gravity may be as low as 1.8. The commercial grades depend on the purity, color, and fineness. "French chalk" is a high-grade of massive talc cut to shape, and used for marking.

Chamois. A soft, pliable leather made from the skins of the chamois, *Antilopa rupicapra*, a small deer inhabiting the mountains of Europe, but now nearly extinct. The leather is light-tan colored, and has a soft nap. It is used for polishing fine plated articles. Chamois is widely imitated with lamb and split sheep skins, by impregnating with fish oils and subjecting to a special tannage. The leather will withstand soaking in hot water, and will not harden on exposure. When tanned with formaldehyde it will not absorb cold water.

Champion steel. The trade name of a high-speed steel intended especially for tools for cutting alloy steels and hard steels, or hard cast iron. It is a product of the Crucible Steel Company of America. It is hardened at from 2,250 to 2,350 deg. F. See High-speed steel.

Charcoal. An amorphous form of carbon, made by enclosing wood billets in a retort and exposing to a red heat for 4 or 5 hours. It is also made by covering large heaps of wood with earth, and permitting them to burn slowly for about a month. Wood charcoal is a velvety, porous, black substance, with a specific gravity of 1.5 to 2. It is insoluble in water. Charcoal is used as a fuel, for gunpowder, for carbonizing, and as an absorbent.

Charcoal for gunpowder is made from alder, willow, or hazel wood. Absorbent charcoals are usually from coconut shells. They are often marketed under trade names. See Activated charcoal. A cubic inch of boxwood charcoal will absorb 90 cu. in. of ammonia gas. Commercial wood charcoal is made with a yield of about 25 per cent of the weight of the wood, and is not pure carbon. The average composition is 95 per cent carbon, 1.5 per cent nitrogen, 0.5 per cent hydrogen, and 3 per cent ash. It is an excellent fuel, burning with a glow at low temperatures, and with a pale blue flame at high temperatures. With an air blast it can be used for smelting iron. Red charcoal is wood charcoal made at a low temperature, and retaining much oxygen and hydrogen. Animal charcoal is produced by heating bones or dried blood in a closed retort. It is used as a paint pigment, or in decolorizing. "Filt-char" is a trade name for a bone charcoal used for filtering. See also Bone black.

Charcoal iron. A grade of pig iron made in the charcoal furnace. It has greater strength than ordinary foundry pig iron, and also has a tendency to chill. It is employed for castings requiring strength and a hard outer surface, such as car wheels. A standard composition is 3.5 per cent of total carbon, 0.70 of silicon, 0.40 of manganese, 0.50 of phosphorus, and 0.08 of sulphur. Charcoal pig iron is also used for making a high grade steel in special "knobbling" furnaces for use in the production of boiler tubes.

Cheddite. A French high explosive used for blasting and for military purposes. It consists of a chlorate with an oily material, such as castor oil thickened by having a nitro-hydrocarbon dissolved in it. The name comes from Chedde, Haute Savoie, where it was first made. A typical cheddite is composed of 80 per cent of potassium chlorate, 8 of castor oil, and 12 per cent of mono-nitro-naphthalene. When made with sodium chlorate it is more insensitive to detonation, and is hygroscopic, but is more powerful. Cheddite is a soft, yellowish material of fine grain, and

can be easily compressed. If greatly compressed the sensitiveness is diminished. It is a slow, mild explosive that splits rocks rather than shatters them, although some of the sodium chlorate mixtures are very violent. Cheddite is usually put up in sticks 2.5 cm. in diameter, and 22 cm. long.

Cheesecloth. A thin, coarse-woven cotton cloth of plain weave, 40 to 32 count, and of coarse yarns. It was originally made for wrapping cheese, but is now employed for many industrial purposes including wrapping, lining, interlining, filtering paints and enamels, and for polishing cloths. The used cloth after washing is employed for wiping machines. Cheesecloth is either bleached or unbleached, and is unfinished. For industrial uses it should not be sized. It is in effect a loosely-woven muslin, and shrinks badly on washing. Various grades are marketed. It comes in "bolts," usually 36 in. in width. For polishing fresh enameled parts a fine grade known as "beef cloth," made of No. 22 yarn or finer, is preferred.

Cherry. The wood of several varieties of cherry trees native to Europe and the United States. The wood is generally brownish to light-red in color, and darkens on exposure. The weight is about 40 lb. per cu. ft. The grain is close, firm, and even. It takes a beautiful polish, and is prized for cabinet work, and for panelling and instrument cases. It is also used for small foundry patterns as a substitute for mahogany. English cherry is from the trees *Prunus cerasus*, and *Prunus avium*. American cherry is from *Prunus aeritina*, the black cherry, and from *Prunus emarginata*.

Chestnut. The wood of the trees *Castanea vulgaris*, *Castanea dentata*, and *Castanea sativa*, of Europe and North America. The trees grow to a large size and yield timbers suitable for large beams, but the wood is cross-grained and much inferior to oak in strength, though similar in appearance. It is more brittle than oak, and the trees are often

of spiral growth. The wood is fairly hard, and has a coarse, open grain. The weight is about 38 lb. per cu. ft. The color is light-brown to white. It is used for posts and beams, and is very durable. A total of 308,091,000 board feet was produced in the United States in 1925. The wood contains from 7 to 8 per cent of tannin, and from it is made an extract used for tanning leather. The dark-brown ovate seed nuts of the European, or "Spanish," chestnut enter the markets in large quantities and are widely exported, especially from Italy. The nuts of the American species are smaller and sweeter, but are not plentiful.

China clay. The common name for the fine variety of clay called kaolin, used for chinaware and insulators. The latter word is thought to be a corruption of the Chinese Kauling, where China clay was obtained originally. See Kaolin.

Chloride of lime. Also known industrially as bleaching powder, and used widely for bleaching, as a disinfectant, and as a deodorizer. It is a white powder, a calcium hypochlorate, of the composition $Ca(ClO)_2 + 4H_2O$, having a strong chlorine odor. It decomposes easily in water. It is made by passing chlorine gas through slaked lime.

Chlorine. An elementary substance, symbol Cl, which at ordinary temperatures is a gas. It derives its name rom its greenish-yellow color. It occurs in nature in great abundance in combinations, in such compounds as ommon salt. It has a powerful, suffocating odor, and is trongly corrosive to organic tissues and to metals. Industrially, chlorine has a great variety of uses in its various ompounds. For bleaching it is widely employed in the orm of compounds that are easily broken up, the chlorine eplacing the hydrogen in the organic material to be bleached. The specific gravity of chlorine is 2.44. It liquefies readily nder pressure. Some of its uses include the making of isinfectants, explosives, and poison war gases.

Chloroform. A liquid of the composition $CHCl_3$, known chemically as tri-chloro-methane, and used industrially as a solvent for greases, vegetable oils, resins, and paraffine, and for cleaning fabrics. It is also employed in medicine as an anesthetic. Chloroform is prepared by treating alcohol or acetone with bleaching powder. The specific gravity is 1.499, and the boiling point is 60 deg. C. It is soluble in alcohol. It decomposes easily in the presence of light and air, forming the poisonous phosgene, and for that reason is dangerous as an anesthetic unless pure and fresh. About 1 per cent of ethyl alcohol is usually added to prevent decomposition.

Chloropicrin. A poisonous "gas" of the composition CCl_3NO_2, used with stannic chloride as a poison gas in chemical warfare. It is also employed in fumigating. It is a persistent lethal and lachramatory poison. Chloropicrin is a colorless liquid made from picric acid. The specific gravity is 1.654 at 20 deg. C., and the boiling point is 112 deg. C. It is soluble in alcohol, but insoluble in water. See also Lethal gases, and Poison gases.

Chromel. The trade name of a nickel-chromium alloy used for heat-resistant castings, and for electrical resistance wires and thermocouples. It is a product of the Hoskins Manufacturing Company, Detroit, Mich. Chromel A contains 80 per cent of nickel and 20 per cent of chromium. Chromel P contains 90 per cent of nickel and 10 of chromium. Chromel C has 64 per cent of nickel, 11 of chromium, and 25 of iron. The tensile strength of Grade A is about 120,000 lb. per sq. in., and the melting point is 1,420 deg. C. The melting point of Grade C is 1,390 deg. C., and that of Grade P is 1,435 deg. Centigrade. See also Heat-resistant alloys.

Chrome-molybdenum steel. Any alloy steel containing chromium and molybdenum as the two predominating influencing alloying elements. Chromium gives unusual hardness and toughness to the steel, while molybdenum is claimed to increase its forging properties. The latte

metal also makes the steel air-hardening. Only small amounts are used in the alloy. A chrome-molybdenum steel used in the form of tubing for airplane construction has the following composition: Chromium 0.80 to 1.10 per cent, molybdenum 0.15 to 0.25 per cent, manganese 0.40 to 0.60, and carbon 0.25 to 0.35 per cent. It has a tensile strength up to 95,000 lb. per sq. in., and is slightly air-hardening. It draws well, and tubes with a wall thickness of only 0.035 in. have been made to Air Corps specifications of this alloy. Chrome-molybdenum steels, with more carbon, have great resistance to wear, even at high heat, and are valued for forging-die blocks.

Chrome oxide green. A pigment marketed in the form of dry powder, or ground in oil, and used in paints, enamels, and lacquers. It is a bright-green, crystalline powder of pure oxide of chromium, Cr_2O_3. The specific gravity is 5.04, and melting point 1,990 deg. C. It is insoluble in water. The dry pigment should have a minimum Cr_2O_3 content of 97 per cent, and not over 2 per cent should be retained on a No. 325 screen. The paste should contain 85 per cent of pigment, and 15 per cent of linseed oil.

Chrome-vanadium steel. A chromium alloy steel containing a small amount of vanadium. The latter has the effect of intensifying the action of the chromium and the manganese in the steel. It also aids in the formation of carbides, and increases the ductility. The amount of vanadium is usually from 0.15 to 0.25 per cent. Vanadium is also an excellent deoxidizer, or so-called "scavenger," making the steel free from slag and more homogeneous. Chrome-vanadium steels are used for such parts as crankshafts, propeller shafts, and locomotive frames.

Chromic acid. Also called chromium trioxide. A red, crystalline, strongly acid substance of the composition CrO_3, used in chromium plating baths, and for etching copper. It is also employed in electric batteries, and in tanning leather. Chromic acid is produced by treating sodium or

potassium dichromate with sulphuric acid. The specific gravity is 2.67 to 2.82, and the melting point is 196 deg. C. It is easily soluble in water.

Chromite. An ore of chromium. It is found only in small quantities in the United States. Maryland and California were the only producing States in 1926, with a production of 194 long tons. The imports in 1926 were 215,464 long tons. The composition of chromite is $FeO \cdot Cr_2O_3$, with the iron sometimes partly replaced by magnesium, and the chromium by aluminum. It is commonly massive granular. The hardness is 5.5, and the specific gravity 4.6. The color is iron-black to brownish-black, with a metallic luster. The melting point is about 3,955 deg. F. The world production of chromite in 1926 was 360,000 tons, almost half of which was in Southern Rhodesia and of which 60 per cent was consumed in the United States. Other sources are India, Russia, New Caledonia, Cuba, and Greece. Chromite is employed for the production of chromium, ferro-chromium, and also in making chromite bricks and refractory linings for furnaces. For bricks the ground chromite is mixed with lime and clay and burned. The Indian chromite from Baluchistan is of high grade, and is especially valued for refractory purposes.

Chromium. A metallic element, symbol Cr, employed very extensively in nickel alloys, alloy steels, and for chromium plating. As a plating metal it is very resistant to corrosion, and is also highly wear-resistant. When alloyed with steel in high percentages it makes "stainless steel." Chromium occurs in nature only in combination with other elements. Its principle ore is chromite, which is an iron-chromium-oxide. The chromic iron ore contains 68 per cent of chromic oxide, on which basis it is sold. The metal is obtained by reduction and electrolysis. Chromium is a tin-white metal with a specific gravity of 6.92, and an atomic weight of 52. Its melting point is 2,750 deg. F., and boiling point is 3,992 deg. F. The term "chromium metal" in the trade usually indicates a pure grade of chro-

mium containing 97 to 98 per cent of chromium and not more than 1 per cent of iron, but it may also indicate lower grades with as little as 90 per cent of chromium.

Chromium copper. An alloy of copper with chromium used in the foundry for introducing chromium into non-ferrous metals, especially aluminum alloys to give them high tensile strength. It is marketed in ingot or in "shot" form. A typical analysis as furnished by the Electro Metallurgical Sales Corporation is: Chromium 8 to 11 per cent, copper 88 to 90 per cent, and a maximum of 1 per cent of iron and 0.50 per cent of silicon.

Chromium steel. An alloy of steel with chromium. When the chromium content is high the steels are of great hardness due to the formation of double carbides of chromium and iron. Chromium also refines the structure, increasing the tensile strength and elastic limit without loss of ductility. Chromium steels have great resistance to wear and are valuable for tools, the usual chromium content being about 2 per cent, although special steels with about 12 per cent chromium and 2 to 2.5 per cent of carbon have remarkable wear-resisting qualities. Such steels are used for blanking and cold forming dies for hard metals and for broaches and rolls. They are hardened by quenching in oil. They are deep hardening and belong to the "non-deforming" class of tool steels. Chromium in steel also makes it rustless and heat-resisting. See Stainless Steel, and Heat-resisting alloys.

Chrysochalk. A trade name for a brass containing a high percentage of copper, about 95 per cent, a small percentage of lead, and the remainder zinc. It has a fine color, but easily tarnishes on exposure unless lacquered. It is used for cheap jewelry. See Gilding metal.

Chrysocolla. A minor ore of copper occurring in the oxidized parts of copper veins. It is found in the copper districts of Arizona and New Mexico. It is a hydrous copper silicate of the composition $CuSiO_3 \cdot 2H_2O$. It occurs

in compact masses with a specific gravity of 2 to 2.4, and a hardness of 2 to 4. The color is green to bluish.

Chrysotile. A fibrous variety of the mineral serpentine, which is the chief source of the asbestos of commerce. It is a hydrated silicate of magnesia of the composition $2SiO_2{\cdot}3MgO{\cdot}2H_2O$. It is a widely distributed mineral. The chief sources of the fibrous chrysotile are the Province of Quebec, Canada, Vermont, New York, New Jersey, and Arizona. See Asbestos.

Cinnabar. The chief ore of the metal mercury. It is a mercuric sulphide, HgS, which when pure contains 86.2 per cent of mercury. The ores, however, are usually poor, containing clay, iron oxide, and other materials. The best ores run up to about 7 per cent of mercury, but the average American ore has only 0.5 per cent. About half of the production comes from Italy, and most of the remainder from Spain. Cinnabar has a massive granular structure with a hardness of 2 to 2.5, a specific gravity of about 8, and usually a dull earthy luster. It is brownish-red in color. Cinnabar is not smelted, the extraction process being one of distillation, made possible by the low boiling point of the metal. Special furnaces are used.

Clarite. The trade name of a high-speed steel used for cutting tools. See High-speed steel. It is a product of the Columbia Tool Steel Co., Chicago Heights, Ill. Clarite is marketed annealed, and it can be machined. It forges between 1,650 and 2,000 deg. F. For hardening it is preheated at 1,550 to 1,600 deg. F., then raised to 2,450 deg. F., and quenched in oil. It is then "drawn" at 1,050 to 1,100 deg. Fahrenheit.

Clay. The general name for all earths that form a paste with water and harden when heated. Most clays are composed chiefly of silica and alumina. Clays are used for the manufacture of bricks, tiles, pipes, pottery and porcelain. When subjected to high heat clays become hard, brittle, and

insoluble in water. Kaolins are the purest forms of clay. Clays with 1 per cent of iron burn red, and titanium increases this color. Yellow ochres contain iron as a free hydrate. All clays contain quartz sand and sometimes mica. Fireclay is a refractory clay containing only a small amount of alkali, and is capable of withstanding high temperatures. Calcareous clays are known as marls. Pyrites burn to holes in the brick bordered by a black ring of magnetic oxide, and are objectionable. Limestone in grains burns to free lime which later slakes and splits the bricks. Most of the common brick clays are complex mixed earths. See also Kaolin, Firebrick.

Clebrium. The trade name of a heat-resistant alloy. A typical analysis shows a composition of 2 per cent nickel, 13.1 per cent chromium, 0.75 per cent manganese, 3.6 molybdenum, 1.5 silicon, and 0.26 per cent carbon.

Clevite. An artificial aluminum oxide made in the electric furnace, and employed as an abrasive. It is a product of the Cleveland Abrasive Wheel Company, Cleveland, Ohio. See Aluminum oxide.

Climax metal. A heat-resistant and corrosion-resistant alloy marketed in the form of wire by the Driver-Harris Company, and used as a resistance metal in electrical apparatus. It contains 25 per cent of nickel, 74 per cent of iron, and 1 of manganese. The tensile strength is 75,000 lb. per sq. in., melting point 1,415 deg. C., and weight 0.294 lb. per cu. inch.

Clock brass. A copper alloy containing approximately 62 per cent of copper, 36 per cent of zinc, and 2 per cent of lead. It is a high-leaded brass. The lead gives it the quality of free cutting, and it can be blanked and turned with clean sharp edges. It gets its name from the fact that it is found especially suitable for small clock gears and clock frames stamped from sheets. It is not suited for forming or cupping operations, as it is too brittle to draw easily.

Coal. A general name for a black mineral formed of ancient vegetable matter, and employed as a fuel and for destructive distillation to obtain combustible gases and carbohydrate products. See Coke, Benzene, Ammonia, Tar. Coal is composed largely of carbon with smaller amounts of hydrogen, nitrogen, oxygen, and sulphur. It was formed in various geological ages and under varying conditions, and occurs in several distinct forms. Peat is the first stage, followed by lignite, bituminous, and anthracite, with various intermediate grades. See Anthracite, Lignite, Bituminous coal, and Cannel coal. The mineral is widely distributed in many parts of the world. The value of coal for combustion purposes is judged on its fixed carbon content, volatile matter, and lack of ash. It is also graded by the size and percentage of lumps. Finely-ground, or "powdered coal," is used for burning in an air blast like oil. The percentage of volatile matter declines from peat to anthracite, and the fixed carbon increases. A good grade of coal for industrial power plant use should contain 55 to 60 per cent of fixed carbon, 30 to 37 per cent of volatile matter, and not exceed 8 per cent of ash. The B.t.u. value should be 13,500 to 14,000 per pound.

Cobalt. An elementary metal, symbol Co, generally found with nickel and arsenic. Its chief ores are smaltite, and cobaltite. The metal is obtained by washing and smelting the ores in a blast furnace and then treating the arsenides by a process of chloridizing and dissolving in acids from which a cobalt hydroxide is precipitated. This is changed to Co_3O_4 by heating. Most of the cobalt is obtained from Ontario, but some is also produced from the copper ores of the Belgian Congo. The annual world's production is about 400 tons. Cobalt is a white metal with a reddish tinge, but its power of whitening copper is inferior to that of nickel. It is very hard, tough, malleable, and refractory. The atomic weight is 58.97, specific gravity 8.756, and melting point 2,672 deg. F. The tensile strength of pure cast cobalt is 34,400 lb. per sq. in., but with 0.25 per cent of

carbon this is increased to 61,900 lb. per sq. in. The metal is allied to nickel, but has no useful alloy with copper. Its chief use is for alloying with steels, giving greater hardness and tenacity to the alloy steel. Cobalt is an excellent material for electro-plating on account of its hardness, but it is costly. Cobalt salts are used as driers in paints, and cobalt oxide is used as a blue pigment in pottery. Imports of cobalt in 1926 were 198,669 lb., and of ore 34,782 lb., oxide 287,265 lb. Cobalt is marketed in the form of black oxide containing 71 per cent cobalt, and gray oxide with 76 per cent of cobalt.

Cobaltite. An ore of cobalt. It is a sulph-arsenide of cobalt, CoAsS, and occurs together in varying amounts with gersdorffite, a sulph-arsenide of nickel, NiAsS. Iron is also frequently present. The color is tin-white, with a reddish tone, and a metallic luster. The specific gravity is 5.8 to 6.2. Cobaltite is found in Ontario, Queensland, and Sweden.

Cobalt steels. Cobalt in small proportions is alloyed with the special steels to give hardness and tenacity. With chromium it develops these properties in the steel to a greater extent. Cobalt up to about 4 per cent increases the ability of high-speed steel to hold its cutting edge. It is used especially in some steels for lathe and planer tools. A high-cobalt steel containing 35 per cent of cobalt is used for permanent magnets, and is claimed to have three times the magnetic strength of the tungsten alloys. See also Stellite, and Widia metal.

Cochineal. A dyestuff of animal origin. Cochineal is the female of the *coccus cacti*, an insect which feeds on various species of cactus in Mexico, Central America, the Canary Islands, and in Java. The insects have no wings, and at the egg-laying season are brushed off the plants, killed by boiling, and dried. It is dark reddish-brown in color. Cochineal contains from 10 to 20 per cent of pure coloring matter, carminic acid, $C_{22}H_{22}O_{13}$, mostly in the eggs,

from which the carmine red, $C_{11}H_{12}O_7$, is obtained by boiling with mineral acid. Carmine red produces brilliant lake colors of various hues with different metals. Commercial cochineal is often adulterated with starch, kaolin, red-lead, or chrome-red.

Cocobola. The wood of a hardwood tree of Central America of undesignated species. It is a beautiful wood, extremely hard, and very heavy, the weight being 75 to 85 lb. per cu. ft. It has orange and red bands with dark streaks, and takes a fine polish. The commercial wood comes from Panama and Costa Rica, and is used for canes, turnery, inlaying, and handles. The wood comes only in small pieces.

Coconut charcoal. An "activated," or highly absorbent charcoal made by heating coconut shells in a closed retort to 900 deg. C. at atmospheric pressure for about 12 hours. The material is then crushed into pieces about 0.10 in. in diameter, and steam treated at 950 deg. C. for 7 hours. Coconut charcoal is also known under various trade names, such as Dorsite and Norit. It is used in gas masks, and for purifying acids and liquors. See Activated charcoal.

Cocos-wood. The wood of the tree *Brya ebenus* of the West Indies and tropical South America. It is also referred to as West Indian ebony, and also as Cocoa-wood. The sap-wood is light yellow and the heart-wood is a rich brown streaked with yellow. The grain is fine, dense, and even. The weight is about 80 lb. per cu. ft., and the wood is extremely hard. It is employed for turnery and inlay work.

Coir. A fiber by-product of the coconut industry. The fiber is soaked and beaten from the husks and then combed and bleached. The coarse and long fibers are used for brush making, the finer and curly fibers being spun into coir yarn which is used for mats, cordage, and coarse cloths. It can be dyed with aniline dyestuffs. The Ceylon coir yarn is sold in two quality grades, "Kogalla," and "Col-

ombo," with further subdivisions according to thickness and texture.

Coke. The porous, gray, infusible residue left after the volatile matter is driven off of bituminous coal. About 15 per cent of the soft coal mined in the United States is converted into coke. The coal is heated to a temperature of 1,200 to 1,400 deg. C., without allowing air to burn it, and the volatile matter expelled. The residue, which is mainly fixed carbon and ash, is a porous, cellular material of great strength. Its structure and nature makes it a valuable fuel for blast furnaces, burning rapidly and supporting a heavy metal charge without packing. Soft, or bituminous coals, are designated as "coking" and "noncoking," according to their capacity for being converted into coke. The volatile matter is utilized for gas, tar, ammonia, and various oils. Coke is generally a by-product of the gas plants. A short ton of coal will yield 1,386 lb. of coke, 11,000 cu. ft. of gas, 8.6 gal. of tar, 22.2 lb. of ammonium sulphate and ammonia, and 2.9 gal. of light oils. The fixed carbon should be at least 86 per cent, ash should be less than 12 per cent, sulphur not over 1 per cent, and volatile matter should not exceed 2 per cent. The porosity may vary from 40 to 60 per cent. The apparent specific gravity should never be less than 0.8. The true specific gravity is 0.8 to 2.10. In 1925 there were produced in the United States 51,267,000 tons of coke, of which 78 per cent was made by the by-product process. See also Petroleum coke.

Colasta. The trade name of a casein plastic used as a molding material for making ornamental articles, and mechanical and electrical parts. Colasta has a tensile strength up to 5,000 lb. per sq. in., specific gravity of about 1.40, and withstands heat up to 400 deg. F. It is a product of The Colasta Co., Hoosick Falls, N. Y. See Casein plastics.

Cold-rolled steel. Low-carbon, open-hearth steel that has been worked into strips, sheets, or rods by cold rolling.

The carbon content is usually from 0.08 to 0.12 per cent, but higher carbon contents may be used, standard cold-rolled shafting runs from 0.26 to 0.32 per cent. The manganese is usually from 0.30 to 0.80 per cent. After the regular hot rolling has been completed on sheets, they are annealed and pickled, and then passed cold through finishing rolls, which smooth and polish the surfaces, and increases the hardness and tensile strength of the sheet. Only a slight reduction is made in the sheet by cold rolling. For the making of cold-rolled strip steel the slabs after hot rolling are sheared to the desired length, then hot rolled into strip which is wound on a coil. The coils are re-coiled in the opposite direction to loosen the scale, pickled in dilute sulphuric acid, rolled in "breakdown" mills, and annealed. The cold rolling is then accomplished until the desired "temper" or hardness is obtained. It is usually in four tempers, but sometimes in six, from No. 1, hard, to No. 6, which is dead soft. Dead soft steel is for severe drawing and cupping work. It has a minimum tensile strength of 37,500 lb. per sq. in., and an elongation of 40 per cent in 2 in. Medium soft, or quarter soft, is for forming or light drawing. The minimum tensile strength is 42,500 lb. per sq. in., and the elongation 20 per cent. Medium hard, or half hard, is for bending at sharp right angles across the grain. The tensile strength is 50,000 lb. per sq. in. Hard rolled is for flat work and easy punching. The minimum tensile strength is 55,000 lb. per sq. in., and the elongation is 5 per cent.

Colloidal tungsten. A tungsten paste formerly extensively employed for the production of electric lamp filiments. It is prepared by passing an electric arc between roughened tungsten electrodes under water, and then evaporating until a plastic mass is obtained. This material is squirted into filaments. Colloidal tungsten can also be prepared chemically.

Colonial high-speed steel. The trade name of a "severe-service" high-speed steel made by the Colonial Steel Com-

pany. It contains 17.25 to 18.25 per cent of tungsten, 3.25 to 4.0 per cent of chromium, 0.25 to 0.35 of manganese, 0.80 to 1.00 vanadium, and 0.60 to 0.75 of carbon. It is made in crucibles, poured into a ladle, and then cast into large ingots, in order to obtain thorough mixing. It is hardened by preheating to about 1,600 deg. F., then heating rapidly to about 2,250 deg. F., and quenching. It is drawn at 1,100 deg. Fahrenheit.

Colophony. The chemical name for common rosin obtained from the pine, or more properly the rosin before the distillation of rosin oil. The residue after distillation is the rosin of commerce. See Rosin.

Columbian mahogany. The wood of the tree, *Cariniana pyriformis*, of Northern South America. It resembles mahogany, but is heavier, and is a harder wood. See Mahogany.

Columbite. A mineral which is a source of the metal columbium, or "neobium." Its composition varies, and may be $FeO{\cdot}Cb_2O_5$, or $(FeMn)Cb_2O_6$, or it may also contain tungsten and other metals. It is similar in structure and occurrence to tantalite. As the tantalum content increases and replaces the columbium, the specific gravity increases proportionately. Unlike tantalum, columbium has as yet no commercial importance.

Columbium. An elementary metal, chemical symbol Cb. It received its name because it was discovered in an American mineral by Hattchett in 1801. It is also called niobium. It occurs in the minerals columbite and samerskit, but is rather difficult to extract in the metallic state. The metal bears a close resemblance to tantalum. It has a specific gravity of 12.7 and melts at 1,950 deg. C. It is not as ductile and malleable as tantalum. It is insoluble in most acids and not readily attacked by alkali solutions. Columbium has as yet no uses in metallurgy.

Colza oil. A rape oil extracted from French seed. It is used for mixing with mineral oils to make cutting oils. See Rape oil.

Comet metal. A nickel-chromium-iron alloy resistant to oxidation at medium temperatures. It is used as a resistance wire in rheostats and controllers. Comet metal contains 30 per cent nickel, 65 per cent iron, and 5 per cent chromium. Its melting point is 1,480 deg. C. Its resistance is 550 ohms per circular mil.-ft. at 20 deg. C. When hard drawn it has a tensile strength of 160,000 lb. per sq. in. It is made by the Driver-Harris Company.

Commercial bronze. A brass which derives its name from its bronze color. It contains 90 per cent of copper and 10 per cent of zinc. Sometimes it is made up with 88 per cent of copper, 11½ per cent of zinc, and ½ per cent of tin. It is very ductile. The alloy containing tin is less ductile but has greater strength and hardness. Commercial bronze is one of the standard mixtures of the brass mills.

Concrete. One of the most widely used construction materials. It is composed of portland cement, sand, and gravel or broken stone, in the proportions 1 volume of cement to 2 of sand and 4 of stone, but these proportions are varied according to the strength, pureness, and other qualifications required. It is practically artificial rock. The sand used is usually roughly angular, and the stone sharply broken. Concrete to set in water is made with hydraulic lime instead of portland cement. Reinforced concrete is a combination of concrete with a steel internal structure generally composed of rods. It has great strength. Reinforced concrete is extensively used in buildings, bridges, telegraph poles, roads, and many other things.

Condensite. The trade name of a synthetic resin obtained by the action of phenol and hexa-methylene-tetramine, or hexamine. It is covered by U. S. patent 1,102,630. The reaction product is very similar to other

phenol resins such as Bakelite. It is a product of the Diamond State Fibre Company. See Phenol resin.

Condensite celeron. The trade name of an impregnated fiber product employed for molding various parts, especially electrical parts and insulators. It is made from paper or other cellulose material treated with a synthetic resinous varnish made from phenol and formaldehyde or other organic materials. The treated product is "cured" by heat and pressure. Celeron has approximately the same physical properties as a phenol resin. Other grades are made with a base of felted fiber or of woven fabric impregnated with the varnish. These grades are sometimes used for making gears. Celeron is marketed in sheets, rods, and tubes. It can be machined and punched easily. The tensile strength is from 8,500 to 11,000 lb. per sq. in. It is a product of the Diamond State Fibre Company, Bridgeport, Pennsylvania.

Constantan. The trade name of a cupro-nickel alloy containing 45 per cent of nickel and 55 per cent of copper. It is used chiefly for pyrometer and electrical resistance wires. When cold drawn it has a tensile strength up to 140,000 lb. per sq. inch. It is highly resistant to oxidation and corrosion.

Constructal. The trade name of a German light alloy used for airplane and other light construction work. It contains chiefly aluminum and magnesium, with a small percentage of copper.

Cooperite. A trade name for an alloy of great hardness, used for cutting tools in place of high-speed steel. It contains 80 per cent of nickel, 14 of tungsten, and 6 of zirconium.

Copal. A general name for fossil resins found in nearly all tropical countries of the world, and used in making varnishes and lacquers. The hardest and most prized varieties come from Africa. All of the copals are soluble

in alcohol, linseed oil, and in turpentine. The specific gravity is from 1.04 to 1.13. There are many varieties of copal having characteristic odors and colors varying from white through yellow, red, brown, to brownish-black. The commercial copals are classed in five groups: East African, West African, Manila, Kauri, and South American. The name copal is sometimes also applied to the resin from the Malay tree *Agatha alba*. See Dammar. There are seven grades of copal, from the "No. 1 pale, scraped chunks," to "No. 7 dust." Copal is harder than dammar, and has a higher melting point. Copals are also distinguished by their solubility in chloral hydrate.

Copernick. The trade name of a magnetic nickel-iron alloy containing equal amounts of nickel and iron. It does not contain copper. It is employed for transformer cores. The chief characteristic of the alloy is a considerable range of flux density in which the permeability has little variation. It is thus called "constant permeability nickel." The permeability is higher than the best silicon transformer steel when the alloy is properly heat-treated.

Copper. One of the most useful of the metals, and claimed to be the first metal employed by man. It is found native, or in minerals as oxides and sulphides. The chemical symbol is Cu. It has a yellowish-red color, and gives a brilliant luster when polished. It has a disagreeable taste, and a peculiar odor when rubbed. It is tough, ductile, and malleable. It melts at 1,981 deg. F., and boils at 4,180 deg. F. The specific gravity is 8.91, and weight per cu. in. is 0.321 lb. It is the best conductor of electricity next to silver, having a conductivity equal to 92 per cent that of silver. The tensile strength of cast copper ranges from 17,000 to 20,000 lb. per sq. in., and the elongation in 2 in. is 40 to 50 per cent. Hard-drawn wire may have a tensile strength up to 50,000 lb. per sq. in., with an elongation of about 4 per cent. The "bus-bar copper" used by the large electric companies has a tensile strength of 35,000 to 40,000 lb. per sq. in. Silicon is the best known hardener

of copper, but it decreases the electric conductivity even in very small amounts. Copper is used for electric conductors, for making brasses and bronzes, for sheathing, fittings, and for casting articles that are required to be corrosion resistant. Small amounts of copper are also added to some steels to increase the corrosion resistance. The United States produces about 55 per cent of the total world output of copper, and in 1927 had 85 per cent of the total refining capacity. The world production in 1926 was 1,628,000 metric tons. Chilian and Belgian Congo copper are the next in importance. The average copper content of the copper ore mined in the United States is 1.6 per cent, and it is concentrated to 15 or 20 per cent before smelting. After smelting, the copper pigs for the best grades are usually refined electrolytically. Copper is marketed in three grades: Electrolytic, Lake, and Casting. Nearly 60 per cent of the raw copper is sold in "wirebars" of about 200 lb. each for rolling and drawing into wire. Another 25 per cent is sold in ingots. About 50 per cent of all copper goes into electrical uses. Commercial raw copper of high grades is 99.9 per cent pure.

Copperas. A common name for iron sulphate, used as a pigment. See Ferrous sulphate.

Copper carbonate. Also called artificial malachite. A green, poisonous powder of the composition $Cu_2(OH)_2CO_3$, used as a pigment. It is insoluble in water but is dissolved by most acids. The specific gravity is 3.7. It is made by adding sodium carbonate to a solution of copper sulphate.

Copper sulphate. Also called blue vitriol. A substance of the composition $CuSO_4 \cdot 5H_2O$, forming deep, azure-blue crystals of a vitreous luster and a metallic taste. It has a wide variety of commercial uses for electric batteries, dyes, and in many manufacturing processes. A water solution is often used to copper coat the surface of iron or steel for layout and marking purposes. Copper sulphate has a specific gravity of 2.284, a hardness of 2.5,

and it is soluble in water and in alcohol. In its natural form, called chalcanthite, it is a rare mineral found in arid regions and deposited from the waters in copper mines. It is produced commercially by the action of dilute sulphuric acid on copper or copper oxide.

Cordage fibers. Any materials used for making ropes, cables, twine, and cord. Twine is cordage less than $\frac{3}{16}$ in. in diameter, and composed of two or more rovings twisted together. Rope is cordage made by twisting several yarns into strands, and then twisting the strands into a line. A cable is a strong rope, usually referring to the larger sizes. Cord is an indefinite term for twine or for the cotton twines used for wrapping. Manila hemp is the most widely used cordage fiber for ropes of all kinds. Sisal hemp is used in the cheaper grades of cordage. Hemp is also widely employed, and Russian hemp is considered as a superior material for strong ropes. Untarred hemp rope is used for elevator ropes, and tarred hemp is used for rigging. Sunn hemp is a weaker fiber. About 50 per cent of American strong cordage is from manila hemp, and 28 per cent from sisal. Cotton is employed for the weak "cords" and "strings" used for wrapping light packages. Fully 80 per cent of the "binder twine" of the world is made from sisal hemp from Mexico. Seaming twines are made of linen. See Hemp, Sisal hemp, Manila hemp, Sunn hemp.

Core oils. Liquid binders used for sand cores in foundry work. Linseed oil is claimed to be the best binder, but is too expensive for ordinary foundry use. Core oils are usually composed of linseed oil mixed with cheaper vegetable oils or with mineral oils. In some cases fish oil or rosin oil is also used.

Corex. The trade name of an artificial silicon carbide made in the electric furnace and used as an abrasive. It is a product of the Safety Emery Wheel Company, Springfield, Ohio. See Silicon carbide.

Cork. The thick, spongy bark of a species of oak tree, *Quercus suber*, native to Spain and Portugal. It is used for bottle stoppers, insulation, vibration pads, and floats for nets and rafts. The scrap cuttings from the bottle cork industry is used largely for refrigerator insulation, packing for the transportation of fruits, and for the manufacture of linoleum and other materials. The cork tree grows to a height of about 30 ft. After it has attained the age of about 25 years it can be barked in the summer, and this barking is repeated every 8 or 10 years. The quality of the cork improves with the age of the tree, and if properly barked a tree will live for 150 years or more. When dried, cork is light, porous, easily compressed and very elastic. The weight is about 15 lb. per cu. ft. The thickness of the bark varies from ½ to 2 in. Although porous, cork is impervious to ordinary liquids when compressed into stoppers.

Corn oil. Known also as maize oil. A bright-yellow oil obtained from the seeds of the maize or corn plant, *Zea mays*, and used in cutting oils, leather belt dressings and for various other industrial processes. It is classed as a semi-drying oil, having better drying properties than cotton-seed oil. The iodine value is about 120, and the specific gravity is 0.920 to 0.925. Corn oil is also edible and is used as an adulterant of other edible oils. The commercial oil comes from the germ portion of the grain, which contains 20 per cent of oil, and is a by-product in the manufacture of corn starch and glucose. Some oil is also obtained from the fermentation vats in the manufacture of alcohol, although it is different in characteristics from the expressed oil. Corn oil has a distinctive grain odor and taste. In consists largely of the glycerides of oleic and linolic acids.

Corrosiron. The trade name of a silicon-iron alloy having acid-resisting properties. It belongs to the group of high-silicon alloys, and is employed for making castings for chemical apparatus, pumps, and machine parts where resistance to the action of acids is required. It is a product

of the Pacific Foundry Company, San Francisco, Calif. See Silicon-iron alloys.

Corrosion-resistant alloys. Literally this would include any metals offering resistance to corrosion such as the alloys of platinum and the precious metals, but industrially it usually refers only to the great group of alloys having chromium as a base, and alloyed with iron, nickel, cobalt, with sometimes copper, and frequently small quantities of tungsten, molybdenum, or other elements. The chromium, cobalt, and nickel, are the chief constituents, the other metals usually being added to give other properties, such as hardness, or toughness. The proportion of chromium may vary from 4 to 65 per cent, and the cobalt or nickel, or both, may be from 5 to 90 per cent. Iron in proportions from 0 to 80 per cent may be used to replace part of the other three metals, chiefly because of its lower cost. These alloys are marketed under a great variety of trade names, such as Cobaltchrome, Cuniloy, Haynes metal, Illium, Nevastain, Parr metal. The silicon irons, such as Duriron, Corrosiron, and Elianite, containing high percentages of silicon, may also be classed as a group of corrosion-resistant alloys.

Corundum. A crystalline mineral, next to the diamond in hardness, used largely as an abrasive. It is an oxide of aluminum of the composition Al_2O_3. The hardness is 9 on the Moh scale. When pure it is colorless, but it usually contains some other metallic oxides. The word corundum is Hindu, and was first applied to the gemstones of corundum coming from India, but the word is now generally applied to the opaque stones used only for abrasive purposes. The ruby is a red corundum with chromic oxide. The saphire is a blue variety containing titanic oxide, while the Oriental topaz is a yellow corundum containing ferric oxide. Corundum in the form of rubies is employed for pivot bearings in watches. Artificial corundum for use as an abrasive is now made on a large scale and sold under various trade names. It is made by fusing bauxite in the electric furnace. See Aluminum oxide.

Cosmos metal. The trade name of a lead-base white bearing metal containing small amounts of tin and antimony. It is used for shafting bearings. It is a product of the Lumen Bearing Company, Buffalo.

Cothias metal. A base alloy, or hardener, used in making zinc-base, die-casting metals. It contains about 67 per cent of copper and 33 per cent of tin, and comes in small ingots.

Cotton. The white fiber of the calyx, or blossom, of the cotton plant, which belongs to the Mallow family and is abundant in warm climates. It has a very wide variety of uses for making fabrics, cordage, padding, and for producing cellulose for plastics, artificial silk, and explosives. There are many varieties of the plant, yielding fibers of varying lengths, whiteness, and silkiness. The diameter of the fibers varies from 0.0006 to 0.0009 in. The most noted classes are: Sea Island, *Gossypium barbadense;* Egyptian; American upland, *G. hirsutum;* Brazilian; Arabian; and Nanking. The world production of cotton usually reaches 23,000,000 bales of 478 lb. each, 60 per cent being produced in the United States. India, Egypt, and China are also large producers. The American domestic cottons are upland, long staple upland, American-Egyptian, and Sea Island. The short-staple upland is under 1⅛ in. in length, and can be spun only into coarse and medium yarns, but is the most widely grown cotton. Long-staple upland is from 1⅛ to 1⅜ in. in length. Sea Island cotton, grown best in tropical countries, is the longest, finest, and silkiest of the fibers. Its length varies from 1¼ to 2½ in. American-Egyptian cotton, with an average length of 1⅝ in., is used extensively for automobile tire fabrics. True Egyptian, or "Maco," cotton is second in quality to Sea Island. It has a long fiber, a fine luster, and great strength. It also has a remarkable twist, which makes a strong, fine yarn. Peruvian cotton, from *G. acuminatum,* is also of fine quality. The number, or "count," of commercial cotton yarns indicates the number of 840-yd. hanks to the pound; No. 10 cotton yarn contains 8,400 yd. to the pound. "Absorbent cotton" is cotton

fiber that has been thoroughly cleaned and the natural wax removed with a solvent such as ether. It is very absorbent, and will hold water. "Cotton batting" is raw cotton carded into lightly matted sheets, and put up usually in rolls. It is much used for padding purposes.

Cottonseed oil. The most common of all vegetable oils, with more than a billion pounds produced annually in the United States. It is used primarily as a food oil, but it also has a wide industrial use. It is used to mix with and to adulterate mineral and vegetable oils employed as lubricants, cutting oils, quenching oils, and drying oils. It is also made into blown oils. Cottonseed oil is expressed from the seeds of the cotton plant, *Gossypium*, of which there are many varieties. The seed is separated from the fiber by means of a toothed ginning machine, and is a by-product of the cotton textile industries. See Cotton. When the seeds are crushed whole the oil is dark in color, and requires careful refining. The American practice is to "decorticate," or hull the seeds by means of special machinery before crushing. The oil is colorless, nearly odorless, and has a specific gravity of 0.915 to 0.921. Upland cotton seed contains about 24 per cent of oil, which is largely composed of palmitic, linolic, and oleic acids. The residue is caked and sold as a cattle feed. The American oil has an iodine value up to 110. Egyptian and Indian oils are inferior in color to the American, and the Indian oil has a fishy odor, and a fluorescence. Although much used as a food, cottonseed oil is devoid of the vitamin food accessories, and also contains a toxic principle. The oils are refined with a solution of caustic soda. Cottonseed oil stearin is the solid product obtained by chilling the oil and filtering out the solid portion. It has an iodine value between 85 and 100. "Winter-yellow" cottonseed oil is the expressed oil after the stearin has been removed.

Cottonwood. The wood of the large trees *Populus monilifera*, *Populus deltoides*, and several other species, of the United States and Canada. It is a soft wood of a

yellowish-white color and a very fine, open grain. It is sometimes called poplar, or Carolina poplar. The weight is about 30 lb. per cu. ft. The wood is easy to work, but is not strong, and is likely to warp. It is used for packing boxes, panelling, and general carpentry. The production of cottonwood in 1925 in the United States, including aspen and balsam poplar, *Populus balsamifera*, amounted to 142,113,000 board feet. The name cottonwood is also applied to the wood of the tree *Bombax malabaricum*, native to India, Burma, and Ceylon. It is whitish in color, soft, and weighs about 28 lb. per cu. ft. It has the same uses and general characteristics.

Crabwood. The wood of the carapa, or caraba, tree, *Carapa guianensis*, of tropical South America, noted chiefly as a cheaper substitute for mahogany. It has a deep, reddish-brown color, with a moderately coarse grain. It is fairly hard, but inclined to warp. The weight is about 40 lb. per cu. ft. Very large logs are obtainable.

Creosote. A yellowish, oily liquid obtained from the distillation of coal tar. It has the odor of carbolic acid, and is poisonous. Creosote is employed as a wood preservative, and as a harsh disinfectant. The specific gravity is 1.07. It contains the three cresols, ortho, meta, and para, which give it the chief preservative qualities. See also Cresylic acid.

Crescent steel. The trade name of a group of tool steels made by the Crucible Steel Company of America. The steel is marketed in a number of grades, each adaptable for making various kinds of tools and dies. See Tool steel.

Cresylic acid. Also called cresol. A mixture of the three varieties of cresols obtained during the distillation of coal tar. It is employed in making synthetic resins in place of phenol. In combination with phosphoric acid it forms the product known as lindol, used in lacquers and as a substitute for camphor in synthetic resins. The chemical composition is $CH_3C_6H_4OH$. It is a colorless or yellowish liquid, with a

specific gravity of 1.042, and melting point of about 11 deg. C. It is soluble in alcohol. Cresylic acid is not soluble in water, but when mixed with soap is soluble in all proportions, and is used in cutting oils as a disinfectant. Cresylic acid, and the crude creosote oil, owe their preservative qualities to the poisonous acridine which is sometimes separated out and used as an insecticide.

Crinoline. A stiff fabric of very open weave made of coarse cotton yarns and heavily sized. The weave is plain. It was originally made of horse hair and linen, hence its name. It is bleached, or is dyed in plain colors. Crinoline is used industrially as a supporting material for parts made of waxes or composition, such as dictaphone records.

Crocus. A name applied to mineral powders of a deep yellow, brown, or red color used as pigments and for polishing. Polishing crocus is chiefly red ferric oxide, known in the metal-working industry under the name of "rouge." See Ferric oxide.

Crown glass. A white glass, known as soda-lime glass, employed for windows. A typical composition is 72 per cent of SiO_2, 13 of CaO, and 15 per cent of Na_2O. The glass derives its name from the circular "crowning" method of making the sheets. The superior surface of crown glass is partly attributed to the polishing it gets in manufacture.

Crucible steel. A steel made by melting small pieces of wrought iron in a graphite or clay crucible with charcoal and ferro-manganese. In England shear steel and blister steel are used instead of wrought iron. The crucibles usually hold 80 to 100 lb. of iron, and are sealed with a cover and placed in a furnace. The slag separates by gravity from the molten metal, and the oxides combine with the carbon and manganese and boil off. After melting it is held at a high temperature for some time with no boiling. The slag is removed with an iron rod, and the metal run into cast-iron molds, which have been coated with soot and preheated. If large ingots are desired the

contents of several crucibles are poured first into a large ladle. The pouring of the steel into the molds is known as "teeming." The ingots are reheated and hammered, drawn, and rolled into bars. The crucible process is used for making tool steels.

Crushed stone. Stone that has been quarried, crushed, and graded for use in construction work. Crushed stone is the common material for concrete "aggregate." It differs from sand and gravel in having sharp edges, and also from large-sized gravel by being usually composed of only one kind of rock. Graded stone usually begins at ¼ in., and runs by various stages up to 2½ in., although larger sizes are sometimes called for. Screenings range from dust up to about ¼ in. diameter. Crushed stone in the larger sizes is used for concrete, and the smaller grades are employed largely in paving.

Cryolite. A mineral used as a flux in the electric production of aluminum, and in the making of special varieties of glass and porcelain. It is a fluoride of sodium and aluminum, Na_3AlF_6, and occurs in masses having a vitreous luster. The color ranges from white to colorless. It has a hardness of 2.5, and is easily fused. It is produced in Greenland.

Crysolite paint. A rust-resisting and acid-resisting paint employed for painting tanks, smokestacks, steel bridges, and structural steel. The base of the paint is refined retort coke-oven pitch, which is mixed with vegetable drying oils. It is made quick-drying or slow-drying, the former taking 6 to 8 hr., and the latter 12 to 16 hr. The color is black. It is a product of the Semet-Solvay Company, Syracuse, New York.

Crystolite. The trade name of an artificial abrasive marketed by the Macklin Company, Jackson, Mich. It is a silicon carbide made in the electric furnace. See Silicon carbide.

Crystolon. The trade name of an artificial silicon carbide, made in the electric furnace and used as an abrasive and as a refractory for furnace linings. It will withstand temperatures above 2,700 deg. C. Its coefficient of expansion is 0.0000045 per deg. C. It is a product of the Norton Company, Worcester, Mass.

Cufenium. The trade name of a white alloy used for making tableware. It contains 72 per cent of copper, 22 of nickel, and 6 of iron. It is a harder metal than ordinary nickel-silver or cupro nickel, and less malleable.

Cumar gum. A variety of resin made from coal tar, and used in place of vegetable resins for varnishes and enamels. It is a product of the Barrett Company. It has the advantage that varnishes made with it are resistant to soaps and alkalies, but it has the disadvantage that it yellows with age.

Cumerone. A colorless liquid of the composition C_8H_6O, employed in making synthetic resins for molding purposes. Cumerone occurs in the fraction of naphtha boiling between 165 and 175 deg. C. It is isolated by treating with picric acid. The specific gravity is 1.096, and boiling point 172 deg. C. It has a characteristic smell, is insoluble in water, but is easily attacked by oxidizing agents.

Cumerone resins. A group of synthetic resins made by the action of sulphuric or phosphoric acids on cumerone. The cumerone resins, $C_6H_4{\cdot}CH{\cdot}O{\cdot}CH$, are distinguished by their great solubility in many organic solvents, and are thus valuable for paints, lacquers, and varnishes. They can also be used for waterproofing, and are employed in molding compounds and in rubber mixtures as substitutes for rubber. The specific gravity is 1.05 to 1.10. They have a high dielectric constant, but are very brittle unless mixed with other more elastic resins. They also turn yellowish in the light, and are therefore not suitable for use where light colors are employed.

Cuprite. An important ore of the metal copper, also called red copper ore. It is a cuprous oxide, Cu_2O, containing theoretically 88.8 per cent of copper, and occurs usually massive, but sometimes in crystals. The specific gravity is 6, and the hardness is 3.5 to 4. The color may be various shades of red, with an adamantine luster in the clear crystallized form, or a dull earthy luster in the massive varieties. Cuprite is found in the copper deposits in Arizona, and is one of the ores in Chile, Peru, and Bolivia. It also occurs in various places in Europe. See Copper.

Cupro-nickel. Any alloy of copper and nickel. The cupro-nickel alloys were known to the ancients, and are very varied in composition, as nickel and copper form solid solutions in all proportions. The alloys are ductile and malleable, and have a maximum hardness at about 50 per cent of nickel. Cupro-nickel of 2½ per cent nickel is used for the driving bands of shells; 15 per cent cupro-nickel, for bullet jackets and condenser tubes; and 25 per cent, for coinage. Fifteen per cent cupro-nickel can be rolled from 1½ in. in thickness to about 0.040 in. without intermediate annealing. Nickel whitens copper, and gives the alloy a characteristic pinkish-white color. The alloys are apt to absorb gases during melting and annealing, and to scale when heated in the open air. Small amounts of silicon added to cupro-nickel forms a nickel-silicide which enters into solid solution. An alloy patented by Corson contains about 95 per cent of copper, 4 of nickel, and 1 of silicon. It is hard and strong and can be forged or cold rolled.

Curupay. The wood of the tree *Piptadenia cebil,* native to northern Argentina, Paraguay, and southern Brazil, and employed for heavy construction timbers, car building, furniture, and crossties. The wood is very hard, has a reddish color, and a handsome, wavy grain. The weight is about 74 lb. per cu. foot.

Cutch. A name given to the extract from the wood and seed pods of several varieties of acacia trees native to Asia.

It contains a high tannin content, and is used for tanning leather and for dyeing in brown shades. See Catechu.

Cutting oils. Oils employed for lubricating metals being machined. They are usually heavy oils or compounds distinguished from the thin water-soluble oils used for flooding the work with the chief object of keeping it cool. Lard oil is generally recognized as the best cutting oil, but is now seldom used alone because of its cost. It is mixed with mineral and vegetable oils, or with hydrogenated oils. Mixtures of various oils and greases, called cutting compounds, are marketed under trade names, and may also contain disinfectants. The object of the cutting oil is to act as a lubricant between the tool and the work, decreasing the friction. It also carries off much of the heat, enabling the tool to stand up longer under the cutting action. For fine cutting of threads white lead mixed with a heavy oil is also used as a cutting oil. See also Soluble Oils.

Cyanogen. A colorless gas with a pungent odor, poisonous, and inflammable, and used in chemical warfare as a poison gas. The composition is C_2N_2, and it is made by the addition of a solution of potassium cyanide to a solution of copper sulphate. The specific gravity is 1.806, and the liquefying point 21 deg. C. See Lethal gases.

Cyanogen chloride. A colorless, poisonous liquid of the composition $CNCl$, employed as a lachramatory war gas. It causes a copious flow of tears. The boiling point is 13 deg. C., and the solidifying point is -5 deg. C. It is soluble in water, alcohol, and in ether. It is made by treating hydrocyanic acid with chlorine.

Cyclops steel. The trade name of a group of carbon tool steels, high-speed steels, and alloy tool steels of various grades and characteristics. They are products of the Cyclops Steel Company, Titusville, Pa.

Cylinder iron. The name used in the automotive industry for cast iron employed for making engine cylinders,

pistons, and piston rings. The "plain cylinder iron" used by the General Motors Corporation contains 3 to 3.25 per cent of carbon, 0.40 to 0.75 per cent of manganese, 2 to 2.5 per cent of silicon, a maximum of 0.30 per cent of phosphorus, and a maximum of 0.12 per cent of sulphur. The alloy cylinder iron of the same company contains 3 to 3.5 per cent of carbon, 0.50 to 0.80 per cent of manganese, 1.75 to 2.75 per cent of silicon, 1 to 1.5 per cent of nickel, with sometimes a small percentage of chromium, and 0.20 per cent maximum each of phosphorus and sulphur. These irons are very hard, even grained, and generally free from spots or holes.

Cypress. The wood of the cypress tree, *Cupressus sempervirens*, of Europe and Asia Minor. It is a very light, soft wood, but is durable. It is light-brown in color, and has a pleasant, aromatic odor. It is used for furniture, chests, doors, and general construction. The wood known as cypress, marsh cypress, red cypress, or bald cypress, in the United States is from the coniferous trees *Taxodium distichum*, and the "pond cypress," is from *Teascendens*, of the Southeastern States. It is yellowish-red or pink in color, and is a soft wood with an open grain. The weight is about 37 lb. per cu. ft. It is very durable, and is especially valued for shingles or for construction purposes where resistance to weather exposure is necessary. The annual production of cypress in the United States is about a million board feet. Yellow cedar is also sometimes called cypress.

Cystamine. Also called cystogen. A name sometimes applied to the reaction product of ammonia and formaldehyde used for making synthetic resins. See Hexamine.

Dammar. A resin obtained from the coniferous tree *Dammara orientalis*, and several other species of trees of southern Asia and the East Indies, including trees of the genus *Shorea*. It is used extensively in high-grade varnishes and lacquers, and in sealing wax. The specific gravity is from 1.04 to 1.12, and melting point 120 deg. C. It is

soluble in alcohol and in turpentine. To obtain the resin the trees are tapped, and the solidified gum collected after about 3 months. The "Indian dammar" is a fine transparent resin, and is from the tree *D. orientalis*. Black dammar is from the tree *Canarium strictum*, of southern India, and comes in black, brittle lumps, easily ground to powder. White dammar is from the large tree *Agathis alba*, of the Philippines, and is erroneously called Manila copal. It is known locally as "dammar sanum," the word dammar being Malay for resin. The best dammars are from deposits at the bases of the trees, known as "fossil" resins, and also called copal. Dammar is classified as No. 1, colorless chunks; No. 2, slightly yellow chunks; No. 3, discolored chunks; No. 4, chips; No. 5, seeds; and No. 6, dust.

Deal. The wood of the coniferous tree *Pinus sylvestris*, also known by a variety of other names, as Danzig pine, Baltic pine, Scotch fir, northern pine, and fir. It grows widely in northern Europe, United States, Canada, and Asia. The wood is reddish in color, and has a smooth, even, but coarse grain. It is soft, easily worked, tough, and elastic. It is available in large pieces and is a general utility wood.

Decalin. An organic solvent employed as a substitute for turpentine. It is an excellent solvent for oils, fats, and resins. Decalin is known chemically as decahydro-naphthalene, and has the empirical formula $C_{10}H_{16}$. It is made by the hydrogenation of naphthaline. It is a liquid having a specific gravity of 0.884, boiling point 190 deg. Centigrade.

Degami-wood. The wood of the tree *Calycophyllum candidissimum*, of the West Indies, used as a substitute for boxwood. It is also called degami lancewood. The wood weighs 49 lb. per cu. ft., is yellowish in color, and has a fine, dense grain.

Degras. A brownish fat of a disagreeable odor, obtained from sheep's wool by washing, and used for leather belt

dressings, for lubricating grease, and for producing lanolin. It is soluble in alcohol and in benzol. Moellon degras is a by-product of the chamois leather industry. The skins are impregnated with fish oil, and when the tanning is complete the excess unoxidized oil is pressed out and forms the commercial moellon degras.

De Lavaud metal. A trade name for a cast iron made by the centrifugal process. It is properly attributed to a process rather than to the metal itself. It is employed chiefly for making cast-iron pipe. A rapidly-rotating, steel, water-cooled mold is used, the metal being delivered from the end of a horizontal spout which is stationary. The stream of molten metal impinges on the mold and forms a ribbon wound with overlapping edges. The metal is cast hard and brittle, but is annealed for a few minutes at a temperature of 1,750 deg. F. The metal then consists of an outside layer of malleable cast iron, a middle layer resembling steel, and an inner layer of gray iron. It has a high tensile strength, about 32,000 lb. per sq. in., and an elongation of 0.5 per cent in 2 in. The process is used in the United States by the U. S. Cast Iron Pipe and Foundry Company.

Delhi rustless iron. A chromium-silicon-iron alloy having high rust-resisting and acid-resisting properties. It belongs to the class of stainless or rustless steels, but its low carbon content does not permit hardening. It is used for machine parts or for plate work where resistance to oxidation is important. It contains about 18 per cent of chromium, 1.5 per cent of silicon, and not more than 0.08 per cent of carbon, but various other grades are marketed, and it is available in all standard shapes. The specific gravity is 7.67 to 7.77. It can be readily forged. The best grade gives an ultimate strength up to 110,000 lb. per sq. in. when rolled. The melting point of Delhi iron is 2,750 deg. F., and it is claimed to withstand continuous heating up to 1,600 deg. F. without scaling. It is a product of the Ludlum Steel Company.

Delta metal. A trade name for a brass containing iron, with small amounts of lead, manganese, and phosphorus, and first put on the market in 1883 by Alexander Dick as a substitute for the more expensive bronzes. The alloy contains 54 to 58 per cent of copper and 40 to 43 per cent of zinc. The lead, manganese, and iron usually do not exceed 1 per cent of each. The minute content of phosphorus is introduced in the form of a small amount of phosphor-copper, and is for deoxidation. The iron and manganese are added in the form of iron-zinc alloy and manganese-copper. Delta metal has high strength and toughness. It is claimed to produce sound castings, and is also adapted for hot forging or stamping. It is not suitable for cold drawing or bending. Cast Delta metal has a tensile strength of 45,000 lb. per sq. in., and an elongation of 10 per cent. When rolled its tensile strength reaches 75,000 lb. per sq. inch.

Denaturants. A group of substances used for mixing with ethyl alcohol to be used for industrial purposes in order to prevent the use of the alcohol as a beverage. The usual denaturants for commercial denatured alcohol are: Methyl alcohol, pyridine, benzene, kerosene, nitrobenzene, and pine oil. One or several of these may be employed. It is not possible to remove these substances from the alcohol by ordinary distillation, and they are ill-tasting and poisonous.

Denim. A heavy, twill-woven cotton fabric, yarn-dyed usually in either light blue or dark brown. It is widely used for workmen's overalls, jumpers, and work shirts. It also has a limited industrial use where a tough fabric is needed. Art denim, in plain colors or woven with small figures, is used for upholstery. The quality of denim is denoted by its weight in ounces per yard, and by the "count" of the yarn.

Devi-devi. The dried pods of the tree *Caesalpinia coriariae,* native to Central America and the West Indies,

and employed in tanning leather and as a black dyestuff. The pods are about 3 in. long, and contain up to 45 per cent of pyrogallol tannin. The best pods are the thickest and lightest in color. Devi-devi has the disadvantage that it ferments easily, and develops a red coloring matter.

Dextrin. Also called British gum, and amylin. A group of compounds with the same empirical formula as starch, $(C_6H_{10}O_5)_x$, but believed to have a smaller value of x. They have strong adhesive properties, and are used as adhesive pastes, particularly for envelopes and postage stamps, for adulterating gum arabic, in pyrotechnic compositions, and as fillers for cloth. Dextrin is a white, amorphous powder, tasteless and odorless. It dissolves in an equal amount of water to form a syrupy liquid, and is thus distinguished from starch. Dextrin is made by moistening starch or flour with a mixture of dilute nitric and hydrochloric acids, and then exposing to a temperature of 100 to 125 deg. C. Dextrin varies in grade chiefly due to differences in the original starch from which it is made.

Diamond. A highly transparent and exceedingly hard stone of almost pure carbon. When pure it is colorless, but often shows tints of white, gray, blue, red, yellow, or green. It is the hardest known substance, and is placed as 10 on the Moh hardness scale. The diamond always occurs in crystals in the cubical system, and has a specific gravity of 3.521. It has been valued from ancient times as a gemstone, but is also used extensively as an abrasive, and for dies for drawing wire. The stones for the latter purposes are the fragments, or the "bort" unsuitable for cutting into gems. The value of diamonds is determined by their size, color, purity, and freedom from flaws. Diamond splinters as small as $\frac{1}{500}$ carat are cut and facetted. The most valued for gems are of a "blue-white" color. A faint straw color detracts from the value, but deep shades of yellow, red, green, or blue are prized. Most of the diamonds come from India, South Africa, and Brazil. The famous Koh-i-noor diamond is claimed to have weighed

originally 793 carats. The largest South African diamond weighed 288 carats. See also Bort.

Diamond dust. A powder obtained by crushing bort, or from the refuse obtained from the cutting and faceting of gem diamonds. It is used for grinding and polishing hard steels, and for cutting other stones. It is imported largely from France and England.

Diamond fiber. The trade name of a vulcanized fiber. The cellulose which serves as a basis of the material is made from cotton rags. See Vulcanized fiber. Diamond fiber is a product of the Diamond State Fibre Company, Bridgeport, Pa., and is made in several grades of hard and flexible. It is marketed in sheets, rods, and tubes. Hard sheets are made in thicknesses from 0.005 to 2 in., and rods are furnished from $3/32$ to 2 in. in diameter. The fiber has a tensile strength up to 15,000 lb. per sq. in., and a compressive strength of 40.000 lb. per sq. in. It can be machined easily. The dielectric strength is 200 to 400 volts per mil of thickness. It is employed for electric insulation, for gears and for bushings.

Diatomaceous earth. A class of compact, granular or amorphous minerals composed of hydrated silica of the same chemical composition as the opal. It is used industrially as an abrasive, a filtering medium, a filler for paints and compounds, an absorbent, as a heat insulator, and in making some concretes. Tripoli and kieselguhr are varieties of crystalline diatomaceous earth. As a filler it has many applications in phonograph records, soaps, papier mache, plastics, and paints. The American production of diatomaceous earth, excluding tripoli, is about 60,000 tons annually, and is produced in many States. After mining, the material is crushed and calcined. When pure the earth is white, but with impurities it may be gray, brown, or greenish. For insulating purposes bricks or blocks are sawed from the solid or molded from the crushed material. As a heat and sound insulator in building construction

it may also be used in pulverized form. The apparent density of the material is usually 12 to 17 lb. per cu. foot. See also Tripoli and Kieselguhr.

Di-chlor-ethylene. A liquid of the composition $C_2H_2Cl_2$, which is the best solvent for rubber, and is also used as a substitute for ether in the extraction of fats. The liquid has a specific gravity of 1.278, and a boiling point at about 52 deg. C. It is prepared by the reduction of tetra-chlor-ethane with zinc dust.

Die-casting metal. Any alloy employed in making parts by casting in metal molds, or "dies." It may vary widely in composition and color, although all of the die-casting alloys are usually whitish. The three important groups of die-casting metals used in industry are: Aluminum base, zinc base, and copper base. Lead-base alloys are also used, but mostly for casting ornaments and toys. An aluminum alloy used by one of the large automobile manufacturers consists of 90 per cent aluminum, 4 copper, 4 nickel, and 2 silicon. It casts well, is tough and ductile, and has a silvery-white color. It has a tensile strength of 21,000 lb. per sq. in., and a Brinell hardness of 38. A typical copper-base alloy contains 64 per cent of copper, 36 of zinc, and is a true brass. The tensile strength is 40,000 lb. per sq. in. A typical zinc-base alloy contains 88 per cent of zinc, 8 of tin, and 4 of copper. The tensile strength is 35,000 lb. per sq. in., and the Brinell hardness is 55 to 65. It is quite brittle, and will not withstand shocks. Aluminum, or a higher zinc content, may be employed to replace the tin. A zinc-base alloy used for automotive parts contains about 92 per cent of zinc, 5 of aluminum, and 3 of copper. The strength is fairly high, and it is resistant to corrosion. Tin-base alloys are not frequently used because of the cost of tin.

Dinas silica. An English refractory material which is essentially silica with lime as a binder. It is practically the same as ganister. A typical composition is about

97 per cent of SiO_2, and small amounts of Al_2O_3, Fe_2O_3, and CaO. The melting point is about 1,680 deg. Centigrade.

Diphenyl-chloro-arsine. Also known as sneezing gas, and called "blue cross" during the world war. It is a solid substance having a melting point of 44 deg. C., and a boiling point of 333 deg. C. The composition is $(C_6H_5)_2AsCl$. The manufacture is extremely complicated chemically. Diphenyl-chloro-arsine is usually thrown in high-explosive shells, which on bursting disseminate the poison in a fine mist. This vapor penetrates the ordinary type of gas mask, compelling its removal, and thus allowing more poisonous gases to be inhaled. Diphenyl-chloro-arsine affects chiefly the nose and throat, but is also a lethal poison. See also Poison gases.

Diphenyl-cyano-arsine. A violent "sneezing gas" poison used in chemical warfare. It has the composition $(C_6H_5)_2AsCN$, and is made by treating diphenyl-chloro-arsine with a saturated solution of sodium cyanide. Besides attacking the nose and throat the vapor from the poison causes great pain, dizziness, and is lethal. See also Poison gases.

Diphosgene. An important lethal war "gas." It is in reality an oily liquid of specific gravity 1.652, and boiling point of 128 deg. C. Its composition is $ClCOOCCl_3$. It was originally prepared from phosgene, but is more simply made from methyl alcohol and formic acid with chlorine. It has an asphyxiating odor. Diphosgene was known as "green cross" during the world war. It is chemically known as trichloromethyl chloroformate, and is also called superpalite. See also Lethal gases.

Disfico board. The trade name of a fiber board made by the Diamond State Fibre Company, Bridgeport, Pa. It is made of felted and pressed jute and hemp fibers. The weight is 24 cu. in. per lb. The board is produced in red, gray, and black colors, and is marketed in sheets from 1/32 to 1/4 in. in thickness. It is used largely for making trunks and boxes.

Disinfectants. Substances used for killing germs, bacteria, or spore, and thus eliminating causes of disease or bad odors. In medicine the term antiseptic is employed in a similar sense. Certain disinfectants are also used industrially as preservatives for leather and other organic materials. Disinfectants, especially cresol compounds, are used in cutting oils to prevent disease. Phenol, or carbolic acid, is the best known disinfectant, and the germ-killing power of other chemicals is usually based on a comparison with phenol. Practically all bacteria are killed in a few minutes by a 2 to 3 per cent solution of phenol in water. Cresol, cresylic acid, and creosote oil are employed in emulsions in disinfecting sprays, dips, and in cutting oils. Thymol, $C_{10}H_{13}OH$, an essential oil obtained from the thyme plant, is a valuable disinfectant used in ointments, soaps, and solutions. Another important disinfectant is formaldehyde. It has a high germicidal action, and is safe in handling. It is considered an excellent preservative for hides and leather. Chlorine compounds are also used as disinfectants. For the disinfection of germ-carrying men during the World War they were subjected for 10 to 15 minutes to an antiseptic atmosphere produced by spraying chloromine-T, guaiacol, argyrol, or iodine.

Dolomite. A mineral employed for the manufacture of some cements, for making magnesia used in refractory linings for basic-steel converters, and as a flux in melting iron ores. For fluxing purposes, it is simply crushed into small pieces. For furnace linings it is first burned. It is also used as a building stone. Dolomite is a carbonate of calcium and magnesium, and has the composition $CaMg(CO_3)_2$. It occurs in coarse, granular masses, or in fine-grained compact form. The specific gravity is 3.5 to 4. It may be colorless, pink, white, gray, green, or black. It is found widely distributed in rock masses as dolomite limestone, and marble. See also Fluxing stone.

Douglas fir. The wood of the tree *Pseudotsuga douglasii*, of the Northwestern United States and British Columbia.

It is sometimes called Oregon pine or Douglas pine, but the tree is not a pine, being allied to the hemlock fir. The wood has a reddish-yellow color. The grain is even and close, with resinous pores less pronounced than in pitch pine. It is a soft wood, and is fairly durable. The weight is 34 lb. per cu. ft. It is used for general construction work, crossties, and where large timbers are required. It is less costly than pine. It is considered inferior to ordinary pines, but is superior to Brazilian pine. The trees grow to great heights, the average being 80 to 100 ft., with average diameters of 2 to 4 ft., although the trees sometimes reach 300 ft. in height. The American production of Douglas fir in 1925 was 8,154,000,000 board feet, mostly cut in Washington and Oregon.

Drawing paper. A heavy paper, usually buff or white in color, employed for making drawings. For mechanical drawings the buff color is preferred, as it is claimed to be easier on the eyes, and is not so readily soiled. Drawing papers are made smooth or rough, the first type being hot-pressed, and is used most extensively for pencil drawings. Good grades of drawing paper will permit considerable erasure without destroying the appearance, and will also retain the fine pencil lines when the surface is coated with shellac for shop use. Drawing paper is marketed in rolls of widths from 30 to 72 in., and in standard sheets varying in size from "cap," 17 by 13 in., to "antiquarian," which is 52 by 31 inches. The usual standard drawing sheet sizes in the United States are: 9 × 12 in., 12 × 18 in., 18 × 24 in., 24 × 36 in., and 36 × 48 inches.

Driers. A group of substances used for increasing the rapidity of drying of paints and varnishes. The chief function of these driers is to absorb oxygen from the air and transfer it to the linseed oil, thus accelerating its drying to a flexible film. They are in reality catalyzers. Driers are chiefly oxides of lead, cobalt, or manganese, such as cobalt linoleate and pyrolusite. Metallic salts of organic acids, such as aluminum resinates and aluminum palmitate, also

have this property. Lead and manganese compounds together act more effectively as driers than either alone. Lead resinate gives toughness of film as well as drying power. Certain oils, such as tung oil, have inherent drying properties, and are classed as drying oils, but not as dryers. Solutions of dryers are called liquid dryers, and it is in this form that the user of the paint or varnish adds the dryer. Excessive use of driers will destroy the toughness of the film, and cause the paint to crack.

Drill. A stout, twilled, cotton fabric used for lining, and where a strong fabric is required. It comes bleached, unbleached, or piece-dyed. It is made in various weights, and is designated in ounces per square yard. Tan-colored drill is called khaki.

Drill rod. Tool-steel round rod made to a close degree of accuracy, generally not over or under 0.0005 in. the diameter size, and usually polished. It is employed for making drills, taps, reamers, punches, or for dowel pins, shafts, and rollers. Common drill rod is of open-hearth high-carbon plain tool steel, and is marketed in an annealed condition. It can be hardened by quenching in water or in oil. The usual commercial sizes are from 1½ in. in diameter down to No. 80, which is 0.0135 in. in diameter, and the lengths are 1 ft. and 3 ft. The sizes are by the standard of drill gages, with about 200 different diameters. The carbon content is usually from 0.90 to 1.05 per cent, with 0.25 to 0.50 of manganese, 0.10 to 0.50 of silicon, and a maximum of 0.04 per cent of phosphorus or sulphur. It also comes in "high-carbon" with from 1.50 to 1.65 per cent of carbon and 0.15 to 0.35 per cent of manganese. Drill rod can also be obtained regularly in high-speed steels, and some steel mills furnish it in special alloy steels. Some mills also furnish square rods to the same accuracy under the name of drill rod, although these are not technically drill rods.

Drop black. A black pigment for paints, made from the spent bone black from the sugar-refining industry. See Bone black.

Drying oils. Vegetable or animal oils which are easily oxidized by exposure to the atmosphere, and employed in paints and varnishes. The drying of an oleo-resinous varnish takes place in two stages. First, the reducer or solvent evaporates, leaving a continuous film composed of gums and drying oil. The drying oil then is oxidized by exposure, leaving a tough, relatively hard skin. This oxidation is hastened by metallic oxide "dryers," but the drying oil itself is responsible for the film, and the oxides are simply catalyzers. The drying power of oils is measured by their "iodine value," as their drying power, or power of absorbing oxygen from the air, is directly proportional to their power of absorbing iodine. The best commercial drying oil is tung oil. Linseed oil is the most common. It has a high drying power, and is easily available. Linseed oil alone will take seven days to dry, but can be quickened to a few hours by the addition of metallic oxide dryers. Other drying oils are stillingia oil, niger-seed oil, and n'gart oil. The latter is from the kernels of the seed nuts of a climbing plant of Africa, and is equal in drying power to linseed oil. Menhaden and other fish oils are used as drying oils or to adulterate vegetable drying oils, but the film left by fish oils is in general much inferior to that from vegetable oils. See also Blown oils.

Duck. A strong fabric having a very wide variety of industrial and commercial uses. It is employed for sails, awnings, tents, heavy bags, machine coverings, aprons, and where a very heavy fabric is required. Duck is usually made of cotton, but is sometimes of linen. It is woven plain, but with two threads together in the warp. It is made in various weights, and is designated by the weight in ounces per square yard. It is marketed bleached, unbleached, or dyed in colors. When woven with a colored stripe, it is called awning duck. Russian duck is a fine variety of linen duck.

Duplate. A trade name for a non-shatterable glass used for automobile windshields and windows. It is a product

of the Pittsburgh Plate Glass Company, Creighton, Pa. It consists of two sheets of plate glass, each about 1/8 in. thick, with a sheet of transparent Pyralin between. The whole is cemented together by compressing under heat and hydraulic pressure. By special processing the resultant product is made highly transparent. When subjected to a severe blow it will crack without shattering. "Bullet-proof" glass under the same trade name consists of three layers of plate glass and two of Pyralin put together by the same process. It is from 1 to 1.5 in. in thickness.

Duraloy. The trade name of a chromium-iron alloy valued as a corrosion-resistant and acid-resistant metal for making such articles as valves and pump parts. There are various grades containing from 16 to 30 per cent of chromium. It is a product of The Duraloy Company, Pittsburgh, and is supplied in castings, sheets, plates, bars, and tubes.

Duralumin. A light alloy used for airplane work and light machine parts. It contains 3 to 4.5 per cent of copper, 0.4 to 1 per cent of magnesium, 0 to 0.7 per cent manganese, and the remainder, more than 90 per cent, of aluminum with small quantities of iron and silicon. It has the peculiar property of age-hardening. It is quenched from a temperature of about 950 deg. C., and then allowed to stand for a period of 4 days. Annealed Duralumin has a tensile strength of 28,000 lb. per sq. in., an elongation of 18 per cent in 2 in., and a Brinell hardness of 50. After heat-treating and aging for 10 days it has a tensile strength of 59,000, elongation of 18 per cent, and Brinell hardness of 95. Most of this "aging" is accomplished in the first day, and is nearly complete at 4 days. Quenching is done preferably in hot water. Duralumin is annealed by raising to a temperature of 650 deg. F., and cooling. The alloy is more plastic than brass. It can be cold worked, drawn, or forged. It can be welded, but only soldered with difficulty. Sheet Duralumin, 0.008 in. in thickness, is used in place of fabric for the sides of rigid dirigible airships. It has the

disadvantage that it corrodes easily. The weight is 175 lb. per cu. ft. German Duralumin is of a different composition. It contains 88 per cent of aluminum, 2 of copper, and 10 of zinc. Duralumin is the product of the Bausch Machine Tool Company.

Durana metal. The trade name of a brass alloy containing iron, aluminum, and tin. It is claimed to have great strength, and is especially suitable as a forging brass. It is not adapted for cold drawing. The composition is approximately 65 per cent of copper, 30 per cent of zinc, 1.5 per cent of iron, 1.5 per cent of aluminum, and 2 per cent of tin.

Durez. The trade name of a phenol molding resin employed for making electrical and mechanical parts and various other articles. It is marketed in powder form in various colors, and the molding is done at a pressure of 2,000 lb. per sq. in., and a temperature of 350 deg. F. The tensile strength is 4,500 lb. per sq. in. The compressive strength is 32,000 lb., and the specific gravity is 1.33 to 1.91, depending upon the grade and type of filler. It is practically a non-conductor of electricity. It is a product of the General Plastics Corporation, North Tonawanda, N.Y. See Phenol resins.

Duriron. The trade name of an acid-resistant alloy made by the Duriron Company, Dayton, Ohio. It is essentially an iron silicide, giving nearly the same acid resistance as glass, and a strength about the same as cast iron. The metal contains about 14.5 per cent of silicon, 1 per cent of manganese, carbon, and impurities, and the balance iron. It is white, extremely hard, and cannot be machined. It is cast in a similar manner to cast iron, and finished by grinding. The melting point is 2,300 deg. F. The weight is 0.253 lb. per cu. in., tensile strength 10,000 lb. per sq. in. Duriron is used for machine parts where corrosion-resistant and acid-resistant properties are valuable.

Durite. The trade name of a synthetic resin made from phenol and furfural, and employed for molding various products, and also for impregnating fiber to make vulcanized fiber. It is covered by U. S. patent No. 1,398,146. See Phenol resins.

Dyestuffs. Substances employed for giving color to textiles, paper, leather, wood, or other articles. They may be either natural or artificial. The natural dyestuffs are mineral, animal, or vegetable, but the artificial dyes are mainly derived from the coal-tar colors. Tyrian purple, from various Mediterranean snails, was in ancient times the most noted of the animal dyestuffs. Cochineal is another animal dye. Vegetable dyestuffs may be water solutions of woods, barks, leaves, or flowers. These include Brazil wood, sappan wood, fustic, logwood, madder, henna, saffron, annatto, indigo, and alkanet. Mineral dyestuffs include: Ochre, chrome yellow, and Prussian blue. Dyes are "acid" when they operate best in an acid bath, and "basic" when operative in an alkaline bath. Mordant dyes are those that do not operate well without the use of a mordant. Coal-tar, or "analine," dyes are made synthetically in all colors and shades. They are more intense, brighter, and faster than natural dyes. More than 3,000 coal-tar dyes have been manufactured. The production of coal-tar dyes in the United States in 1926 was 88,000,000 pounds. See also Analine.

Dynamite. A high explosive much used industrially for blasting in mining, and in construction work. It was first made by Alfred Nobel in 1867, and consists of nitro-glycerin in an absorbent material, usually kieselguhr. One part of kieselguhr to three parts of nitro-glycerin is molded into sticks, and made up in paper-encased cartridges. It is reddish-brown in color. The sticks are usually arranged for exploding with a detonating fuse.

Eastern cottonwood. A variety of cottonwood lumber from the tree *Populus deltoides*, of the eastern states of the

United States, especially from the lower Mississippi Valley. See Cottonwood.

East India walnut. The wood of the tree *Albizzia lebbek*, of tropical Asia and Africa, having a wide variety of uses for furniture, flooring, panelling, and decorative work. It is a hard, dense, close-grained wood having a weight of about 50 lb. per cu. ft. The color is dark-brown with gray streaks. It takes a fine glossy polish. The logs come as large as 30 in. square, and 20 ft. long. The shipments of East India walnut are likely to be mixed with *Albizzia procera*, the "white siris wood" of India. This wood has a brown walnut color, is lustrous and streaky, and resembles true walnut more than does the East India walnut.

Ebonite. A trade name for black vulcanized rubber made generally from the cheaper grades of rubber, and employed for electrical parts, handles, and novelties. It is hard and brittle. For many of the most important uses, such as fountain-pen holders, ebonite has now been largely replaced by synthetic resins.

Ebony. A hard, black wood valued for parts subject to great wear, and for inlaying. It is the wood of various species of trees of the ebony family, *Ebenaceae*, although the name is also sometimes applied to some woods of the genus *Dalbergia*, family *Leguminosea*. "Black ebony," from the tree *Diospyros dendo*, of West Africa, and "ebony," from the tree *Diospyros melanoxylon*, of India, are the true ebonies. Black ebony has a black heart-wood with brownish-white sap wood. It is extremely hard, being next to lignum vitae in hardness. It has a fine, open grain. The weight is 78 lb. per cu. ft. It is used for inlaying, piano keys, and turnery. Ebony, of India, is also extremely hard, with a fine and even grain. The heartwood is black with brownish streaks. The weight is about 78 lb. per cu. ft. It has the same uses as African black ebony. Various other species are also exported from India and Africa, "Marble ebony" is from a species found in Madagascar. Ebony

wood is shipped in short billets, and is graded according to the color and the source, as Niger, Macassar, Cameroon, etc. "Green ebony" is a name sometimes given to the cocos-wood of the West Indies. See also Marblewood.

Egyptian blue. A beautiful blue coloring material composed of a double silicate of calcium and copper represented by the formula $CaO \cdot CuO \cdot 4SiO_2$. It contains no alkali, and resists the action of most chemical reagents. It was originally made by fusing sand, soda, and copper. It was employed by the Romans, and paintings 1,900 years old have retained the color intact. It is now made by fusing a mixture of finely powdered quartz, chalk, copper oxide, and sodium carbonate, and then washing the product with hydrochloric acid.

E.H.W. steel. The trade name of a hot-work die steel produced by the Latrobe Electric Steel Company. It is a product of the electric furnace, and is a special composition high-tungsten alloy steel, used for dies for hot forging. It is marketed in billets, bars, and forgings, and is usually surnished annealed.

Electrite steel. The trade name for special high-speed steels made by the Latrobe Electric Steel Company, Latrobe, Pa. Electrite No. 1 steel contains 18 per cent of tungsten and various other alloying elements. It is marketed in billets, bars, special forgings and cold-drawn rod. It is usually furnished annealed, but also hardened and tempered ready for use. It is especially suited for drills, reamers, and milling cutters. Electrite Uranium is a special alloy high-speed steel containing 14 per cent of tungsten. It is marketed in the same manner as Electrite No. 1, and is especially recommended for heavy lathe tools.

Electrolon. The trade name of an artificial silicon carbide, used as an abrasive. It is a product of the Abrasive Co., Philadelphia, Pa. See Silicon carbide.

Electrolytic iron. A chemically pure iron produced by the deposition of iron by an electric current in a manner

similar to electro-plating. Bars of cast iron are used as anodes, and dissolved in an electrolyte of ferrous chloride. The current deposits almost pure iron on the cathodes, which are hollow steel cylinders. About 0.1 in. of iron is deposited in 30 hours. The deposited iron tube is removed by hydraulic pressure from the cathode or by splitting, and then annealed by heating to 1,900 deg. F. and quenching in a water spray. It is then rolled into plates. Electrolytic iron can be produced 99.965 per cent pure iron, with not over 0.006 per cent of carbon, 0.004 of sulphur, and 0.005 of silicon. It is employed for magnetic cores, for special purposes where ductility and purity are required, and in the manufacture of alloys. Annealed electrolytic iron has a tensile strength up to 42,000 lb. per sq. in., and can be drawn to $\frac{1}{25}$ of its original diameter without further annealing.

Electromet. The trade name for a group of ferro-alloys, and alloys of chromium and manganese. They are the products of the Electro Metallurgical Company, New York. See Chromium-copper, Ferro-chrome, Manganese-copper, Manganese-silicon, Silicon-spiegel.

Elektron. A German light alloy used for automotive engine pistons and other light parts. The general composition is: Magnesium 95 per cent, zinc 4.5 per cent, and copper 0.5 per cent. The alloy is made by gradually melting the magnesium with a hardener which carries the zinc and copper. The hardener contains 90 per cent of zinc and 5 per cent of copper. The alloy can be readily cast, and it machines well. The ultimate strength is about 40,000 lb. per sq. in., yield point 26,000, and it gives 18 per cent elongation in 2 in. Chips or small particles of the alloy catch fire easily. The specific gravity of Elektron is 1.80. It is a product of the I. G. Farbenindustrie, A. G. Bitterfeld, Germany.

Elemi. A soft, sticky, opaque, oleo-resin with a pleasant odor, obtained from the "pili" tree, *Canarium luzonicum*, of

the Philippine Islands, and employed for giving body to lacquers. It is substituted for dammar, as it is generally cheaper. Other substitute elemi resins are obtained from various trees of the family *Burseraceae* of tropical America and Africa. The pili trees are hacked or stripped, and the resin flows out and collects on the bark. Each tree yields about 5 lb. per year. "West Indian elemi" comes from the tree *Dacryodes hexandra*, native to Dominica, Martinique, and Porto Rico. Elemi oil is a colorless liquid having a specific gravity of 0.87 to 0.91. It is obtained by distilling the gum.

Elinvar. A French proprietary alloy containing about 12 per cent of chromium, 36 per cent of nickel, and 52 per cent of iron, with possibly small quantities of tungsten and manganese. It is highly resistant to corrosion, but is chiefly valued because of its low thermal expansivity and almost invariable modulus of elasticity. It is employed for making balances for chronometers, and for springs for gages and instruments. The alloy cannot be hardened except by cold working.

Elkonite. The trade name of a copper-tungsten "diffused" metal, employed especially for electrodes in welding machines. It is a product of the Elkon Works, Weehawken, N. J., and is claimed to give from 10 to 100 times the length of service of the common hard-drawn copper electrodes. It is made by diffusion, and is not a true alloy. Elkonite is supplied in various grades, from No. OW, which is easily machined, to No. 3OW25, which can be formed only by grinding. It is usually marketed in rods from 3/16 to 1 in. in diameter. The tensile strength of grade 1OW3 is 208,000 lb. per sq. in., Brinell hardness 225, and compressive strength 16,350 lb. per sq. inch.

Elm. The wood of numerous species of the elm tree, of the United States, Canada, and northern Europe. The common elm, *Ulmus campestris*, is a rather hard wood with coarse, open cross-grain, having dark-brown heart-wood

and white sap-wood. The weight is 36 lb. per cu. ft. American elm, *Ulmus americana*, has a finer grain, and a weight of about 40 lb. per cu. ft. It is whitish-brown in color, hard and tough. Rock elm, *Ulmus racemosa*, is also native to the United States and Canada. It has a very fine, close grain and is slightly heavier. Elm wood is tough and durable, and is used in the making of various implements, wheels and ax handles.

Emery. A fine-grained, impure variety of the mineral corundun, mixed with other minerals, chiefly magnetite. It occurs as a dark-brown granular massive substance, with a specific gravity of 3.7 to 4.3, and a hardness of about 8. It usually contains only 55 to 75 per cent of Al_2O_3. It is used as an abrasive either ground into powder or in blocks and wheels. The grains are graded in sizes from No. 180 mesh, the finest, to No. 8, the coarsest. Emery paper and cloth are usually graded from 24 to 120 mesh, and the grains are glued to one side of 9 × 11 in. sheets. "Flour of emery" is the finest powder, usually the dust collected from the crushing. Emery was found in large quantities on Cape Emeri on the Island of Naxos, from whence it derives its name. It is now largely replaced by artificial corundum for abrasive purposes, which can be graded more uniformly. The total production of natural emery in the United States in 1927 was only 306 short tons. See also Corundum and Aluminum oxide.

Enamel. A protective coating or paint which upon hardening has an enamelled, or glossy face. Ordinary pottery enamels are chiefly composed of quartz, feldspar, clay, soda, and borax, with saltpeter or potash sometimes used as fluxes. The quartz supplies the silica. Such enamels are fusible glasses made opaque by a substance such as oxide of tin for white enamel, cobalt oxide for blue. Platinum oxide is used to produce gray in enamels, and other substances give varying characteristics. In acid-resisting enamels alkali earth silicates are used instead of borates. Enamels applied to ironware are fired at a red

heat. The enamels vary greatly, and for application to a metal article an enamel must have approximately the same coefficient of expansion to avoid cracking. "White glass enamel" is easily fusible and is used for gage and clock dials and for scales. The word enamel in the paint industry refers to paints of ground oxides or sulphates mixed with varnish to give the glossy face. These are applied in the same way as ordinary paints, but they do not have the heavy body of a paint, and require an undercoat or several coats of the enamel. See Varnish.

Enargite. An ore of the metal copper, and also a source of arsenic oxide. It is a sulph-arsenate of copper with a composition $3Cu_2S \cdot As_2S_5$ containing theoretically 48.3 per cent of copper, and 19.1 per cent of arsenic. It occurs crystalline, in columnar, bladed, or massive structure. The hardness is 3, and the specific gravity is 4.43 to 4.45. The color is grayish-black to iron-black, with a metallic luster.

Enduro. The trade name for a "rustless iron" produced by the United Alloy Steel Corporation, Canton, Ohio. It contains a high percentage of chromium, and also silicon. It resists corrosion, and does not scale greatly at forging temperatures. Like ordinary iron it does not change much by heat-treatment. The Brinell hardness ranges from 150 to 225. Enduro is malleable, and can be hot worked or cold drawn. It can also be welded, and machines easily. It is not attacked by nitric acid, and is resistant to most other acids. The ultimate strength of hot-rolled Enduro is 80,000 to 90,000 lb. per sq. in., and the elongation 25 to 30 per cent in 2 in. The specific gravity is 7.62. The melting point is 2,750 deg. F. Enduro is furnished in 4 grades, and in all ordinary commercial forms, and has a wide range of uses for mechanical parts of all kinds.

Engine sand. Also known as traction sand. The sand employed to prevent the driving wheels of locomotives or other vehicles from slipping on wet rails. The largest

amounts are used by the railroads, but street cars also use quantities. Engine sand is usually washed to free it of soft bond and fine particles. The Pennsylvania Railroad requires engine sand to contain at least 95 per cent of silica, all grains to pass through a No. 20 sieve, and be retained on a No. 80 sieve. The commercial consumption of engine sand in the United States exceeds 2,000,000 tons annually.

Erbium. An exceedingly rare metal, symbol Er, which occurs in the rare mineral gadolinite found in Greenland and Sweden. Erbium is supposed to resemble aluminum in its physical properties, but due to its rarity has as yet no commercial use.

Erinoid. The trade name of a casein plastic molding material marketed by the Erinoid Company of England, and the Erinoid Company of America. It is available in rods, sheets, and tubes, in all colors, and is used for the manufacture of a great variety of articles. See Casein plastics.

Etching materials. Acids, or other substances, used for etching on metals, glass, or other material. The usual method is to coat the surface with wax, or other substance not acted upon by the acid, cut the design through with a sharp instrument, and then allow the acid to corrode or dissolve the exposed parts. Beeswax, rosin, asphalt, gum varnishes, or mixtures may be used for the protective surface. For etching steel, a 20-per cent solution of nitric acid in water is used. For very hard steels acetic acid may be mixed with the nitric acid. For high-speed steels, brass, or nickel, a mixture of nitric acid with hydrochloric is used in solution. Copper may be etched with a solution of chromic acid. Glass is etched with "white acid," or with hydrofluoric acid.

Ether. A volatile, colorless liquid made by the reaction of alcohol and sulphuric acid. Ethyl ether, commonly called ether, made from ethyl alcohol, is the only one of

the ethers that has commercial value. Its chemical formula is $(C_2H_5)_2O$, and it is used as a solvent for fats and greases, and in pyroxylin manufacture. It has been known since the 16th century, but was not administered as a human anesthetic until 1842. Ether boils at 34.5 deg. C., and burns readily. The specific gravity is 0.720. A mixture of ether and air explodes when ignited. Ether in small quantities in the atmosphere stimulates plant growth, and is used to "force" fruit and flower growth.

Ethyl acetate. A liquid of the chemical composition $CH_3COOC_2H_5$, made from ethyl alcohol and acetic acid. It is an important solvent, especially for nitrocellulose compounds, varnishes and lacquers. The specific gravity is 0.924, and boiling point 77 deg. C. It has a pleasant, aromatic odor.

Ethyl alcohol. The common beverage alcohol, which when denatured for non-beverage purposes is called industrial alcohol. It is a colorless liquid with a pleasant odor but burning taste. Its chemical formula is CH_3CH_2OH, and its specific gravity 0.79. It is also known as ethanol. It mixes with water in all proportions, and takes up moisture from the air. It burns with a bluish flame and high temperature, yielding carbonic acid and water. It is one of the best solvents, and dissolves many organic substances such as resins and essential oils, making solutions called essences. It is classed as a poison when pure, but is employed as a beverage in many forms. In small quantities it is a narcotic, and is absorbed without digestion. Ethyl alcohol can be made synthetically, but is produced more cheaply by the fermentation of sugars, grains, and starch. It is used as a solvent in varnishes, enamels, explosives, liquid soaps, extracts, perfumes, and drugs, and as a raw product in making other compounds. It is also used as a preserving agent, and as a fuel. Due to its low freezing point, -112 deg. C., it is used in some thermometers, and as an anti-freeze mixture. "Absolute alcohol" is free from water. "High purity" and "grain alcohol" contains

about 95 per cent by volume. "Alcohol is sold by the "proof gallon," containing 50 per cent alcohol by volume.

Ethyl-dichloro-arsine. A lethal poison "gas" used in chemical warfare. It is an oily liquid of the composition $C_2H_5AsCl_2$, having a boiling point at 253 deg. C. It is made by a complicated process from arsenious oxide and ethyl chloride. See also Lethal gases.

Ethyl gasoline. The "no-knock" gasoline used for automobile engines. It contains tetra-ethyl lead, ethylene dibromide, halowax oil (monoclornaphthalene) and red aniline dye. The oil is used to aid lubrication, and the dye is simply for identifying this gasoline. Ethyl gasoline is poisonous when inhaled or taken internally, and various regulations cover its employment in garages. Ethyl compound is marketed for adding to any standard gasoline to make ethyl gasoline.

Ethyl glycol. Also known as glycol, and ethylene alcohol. It is a colorless, syrupy liquid with a sweetish taste, and of the composition, CH_2OHCH_2OH. It has a very low freezing point and is employed as an "anti-freeze" in automobile radiators as it is soluble in water. It has the advantage over alcohol for this purpose that it does not boil away easily. Its boiling point is 197 deg. C., and solidifying point -12 deg. C. The specific gravity is 1.125. It does not dissolve the cellulose enamels like alcohol, and therefore does not injure the car finish for this use. It is also employed as a substitute for glycerin.

Ethyl lactate. The ethyl ester of lactic acid, used as a solvent for cellulose nitrate, cellulose acetate, and pyroxylin plastics, in making lacquers from these substances. Ethyl lactate is a liquid with an aromatic odor, boiling point 150 deg. C., and specific gravity of 1.03. See also Lacquers.

European ash. The wood of the common ash tree, *Fraxinus excelsior*, widely distributed over Europe. The English, French, Hungarian and other ashes are all from the

same species of tree, but they vary somewhat in qualities. The wood is white to grayish-white or brownish. It weighs about 47 lb. per cu. ft., is quite hard, has an even and close grain, and is tough and elastic. When felled in the winter and properly seasoned it is claimed to be very durable. Ash is used for hockey sticks, tennis racquets, tool handles, carriage work, and construction. See also Ash, Japanese ash, and Arkansas ash.

Europium. An extremely rare elementary metal found in monazite sand. The chemical symbol is Eu. It is not yet a commercial article. Its oxide Eu_2O_3, is obtained in the form of a pink powder.

Evans' metallic cement. A cadmium amalgam consisting of 25.99 per cent of cadmium and 74.01 per cent of mercury. The chemical formula is Cd_5H_8. It becomes plastic at about 100 deg. F. and can be kneaded. On cooling it becomes hard and crystalline. See Cadmium amalgam.

Everbrite. The trade name of a copper-nickel alloy used where corrosion resistance is valuable, such as for valves. It contains about 30 per cent of nickel, with the remainder copper, although it may also contain a small amount of chromium. The color is white. It can be rolled or drawn, and also casts easily.

Everdur metal. The trade name of an alloy of copper containing about 4 per cent of silicon and 1 per cent of manganese, but varied somewhat to suit the requirements. For rolling it contains 96 per cent of copper, 3 of silicon, and 1 of manganese. It is claimed to combine corrosive-resistant qualities with high tensile strength and toughness, and is used for pickling equipment, pump parts, pipe fittings, and other parts where corrosion resistance is important. The electrical resistance is high, and it is not suitable for conductors. The melting point is 1,922 deg. F., weight per cu. in. 0.294 lb., and tensile strength, cast, 50,000 lb. per sq. in., or hot rolled, up to 75,000 lb. per sq. in. Everdur is employed for casting, forging, or press

working. It machines like bronze, and in the wrought form its physical properties are similar to mild steel. It is a product of the American Brass Company.

Excelite. A trade name of an artificial aluminum oxide made in the electric furnace, and used as an abrasive. It is a product of the Dominion Abrasive Wheel Co., Mimico, Ontario. See Aluminum oxide.

Excello metal. A nickel-chromium alloy containing 85 per cent of nickel, 14 of chromium, and 0.5 each of iron and manganese. It is used for resistance wires in electrical heating apparatus, and will resist oxidation at temperatures up to about 2,000 deg. F. It is marketed by H. Boker & Company, Inc., New York.

Excelsior. A general trade name for wood wool, or continuous, curly, fine wood shavings, employed chiefly as a packing material to prevent breakage of fragile articles in shipping. The raw material used in its manufacture is mainly aspen and basswood in logs or bolts, or it may be made as a by-product of other wood manufactures.

Expanded metal. Sheet metal that has been slit and expanded to form a mesh, which is used for reinforced concrete work or plaster wall construction. It is made with either a plain diamond-shaped mesh, or with rectangular meshes. One type is made by slitting the sheet and stretching the slits into the diamond shape. The other variety is made by pushing out and expanding the metal in the meshes so that the flat surface of the cut strand is nearly at right angles to the surface of the sheet. Ordinary diamond-shaped expanded metal is used for concrete floors. Expanded metal is made from low-carbon steel, iron, or special metals such as Toncan iron. It comes ordinarily in sheets varying from 8 to 12 ft in length, and 3 to 6 ft. in width, in several thicknesses. It is also made up into metal lath, usually 96 in. long, and from 14 to 18 in. wide.

Expansive metal. An alloy metal which expands on cooling, and is used for filling small holes or defects in metal parts or castings. A typical alloy is composed of 9 parts of lead, 2 of antimony, and 1 of bismuth. The expansion or cooling is due to the effect of the antimony and bismuth, both metals having this property.

Explosive. A substance or mixture of substances which upon application of a blow to a portion of its mass, or by a rise in temperature, is converted in a small space of time into other substances more stable, and occupying more space. The chemical changes thus produced develop a sudden rise in pressure, which is utilized for blasting or propelling purposes. Gun powder is the oldest form of commercial or military explosive, but this has been replaced for military purposes by the modern smokeless powders. Blasting powders are required to be slow acting, and have a shattering effect. Military explosives used as propellants must not give instantaneous detonation, which would burst the gun, but are arranged to burn slowly at first and the explosion does not reach a maximum until the projectile reaches the muzzle. Most smokeless powders have gun cotton as a base. The rapid-acting explosives derived from aniline or benzene are generally used for bombs and torpedoes. Other requirements of explosives are that they must not react with steel or brass, must be stable at ordinary temperatures, and should not decompose easily in storage or on exposure to the air. See Gunpowder, Nitroglycerine, Dynamite, Tetryl, Hexa-nitro-diphenylamine, Trinitrotoluene, Tetra-nitroaniline, Picric acid, Azoimide, Cheddite, Sprengle explosives, Prométhée, Nitrostarch, Mercury fulminate.

Explosive D. The common name for ammonium picrate, $NH_4C_6H_2(NO_2)_3O$. It was patented in 1888, and is important chiefly as a military explosive due to its insensitiveness to shock or friction, making it suitable as a bursting charge in armor-piercing shells. It is soluble in alcohol and in water, and crystallizes in orange-yellow needles. It explodes

when heated to 300 deg. C. It is made by the neutralization of picric acid with ammonium carbonate, or ammonium hydroxide.

Extract wool. Wool that has been recovered from cotton and woolen rags by dissolving out the cotton with acids. It is used as a cheaper substitute for new wool. See Wool.

Fabrikoid. A pyroxylin coated cotton textile made by E. I. du Pont de Nemours & Co., Inc., Newburgh, N. Y. It is waterproof, and is much used for automobile tops and leather substitute. It is made in a wide range from light-coated sheetings to heavy-coated sateens, ducks, and moleskins. It is made of a base of cotton cloth of various weights and weaves dyed a color to approximate the finished color. The pyroxylin jelly is spread on by mechanical knives in successive thin coatings pressed into the cloth. It is passed through plates or rollers under heavy pressure for embossing its surface with grains and designs.

Fahralloy. The trade name of a heat-resistant and corrosion resistant alloy used for making annealing and carbonizing boxes, and for chemical machinery parts. It is made in thirteen grades, containing different percentages of chromium and nickel, and will withstand continuous temperatures up to 2,200 deg. F. without oxidation. Some grades can be machined, and are ductile and malleable, while others are hard and brittle. It is a product of the Southern Manganese Steel Company, St. Louis, Mo. See Heat-resistant alloys.

Fahrite. The trade name of a heat-resisting alloy produced by the Ohio Steel Foundry Company, Springfield, Ohio. It is claimed to produce uniform, sound castings, and is used where resistance to high temperatures is important. See Heat-resistant alloys.

Felt. A fabric of wool, fur, or hair made by matting the fibers together under pressure when thoroughly soaked or steam heated. The matting may also be accomplished by

blowing the wet fibers under a powerful air blast, and then pressing. The animal fibers matt together due to minute scales on their surface. Cotton and other vegetable fibers do not have the property of felting, but felt is sometimes made from a mixture of cotton with wool, hair, or fur. Felt is the most ancient of all fabrics. It has now a wide variety of uses, and is made in many plain colors. Woolen felts are used for padding and lining for instruments and machinery parts and many other industrial purposes. Hair felt is largely used as an insulating material. See Hair felt and Baize. The best felts are employed for hats, and are made of nutria or beaver fur, although vast quantities of rabbit furs or mixed furs and wool are used for hat felts. Felts vary widely due to differences in the quality of the wool or other material, and methods of manufacture. Felt is marketed in many thicknesses.

Ferric oxide. A name given to red iron oxide, Fe_2O_3, found in abundance in nature as the ore hematite, or made by calcining the sulphate. It has a dark-red color and comes in powder or lumps. The specific gravity is about 5.20, and the melting point is about 1,550 deg. C. Red ferric oxide is used as a paint pigment under such names as Indian red, or Persian red, in cosmetic rouge, and in polishing compounds, under the name of "rouge." The brown ferric oxide is made by the action of ferrous sulphate and sodium carbonate. It is not a pure oxide. It is used as a paint pigment. Black ferric oxide is a reddish-black amorphous powder, and is made by burning iron in an excess of oxygen. It has the composition $FeO \cdot Fe_2O_3$, or the same as the iron ore magnetite. Black iron oxide is used as a paint pigment, for polishing compounds, and in heat-treating work for decarbonizing steel. Venetian red is a name applied to red iron oxide pigments mixed with various fillers. Ferric oxide pigments make low-priced paints, which are used for painting structural work. The oxides come chiefly from Georgia, Tennessee and New York. See also Hammer scale.

Ferro-boron. An iron alloy containing about 18 per cent of boron, and used in the making of boron steels. It is prepared by reducing boric acid in a fused bath of iron.

Ferro-chromium. A high-chromium iron alloy used in the foundry for mixing to form chromium alloy steels. It is made from chromite ore by smelting with lime, silica, or fluorspar in an electric furnace. Ferro-chromium contains from 60 to 70 per cent of chromium, from 0.75 to 7 per cent of carbon, and small amounts of manganese, silicon, phosphorous, and sulphur. The so-called high-carbon ferrochromium usually contains 5 or 6 per cent of carbon, and 66 to 70 per cent of chromium. It is used for making tool steels, file and cutlery steel, ball-bearing steel, and automobile steels. It melts at about 1,250 deg. C. It is marketed as "crushed alloy" in sizes up to 2½ in., and as "lump alloy" in lumps from 1 in. to 75 lb. Low-carbon ferrochrome contains 0.10, 0.20, 0.30, 0.50, 1.00 and 2 per cent of carbon, and from 67 to 72 per cent of chromium. It is used for making acid-resisting and stainless steels, and various chromium steels.

Ferro-manganese. A high-manganese iron alloy used for making manganese alloy steels and manganese bronze, and for deoxidizing steels. It is made either in the blast furnace or in the electric furnace. Standard ferro-manganese has 78 to 80 per cent of manganese. British ferro-manganese contains about 7 per cent of carbon, but the American content is usually 5 to 6.5 per cent. Low-carbon ferro-manganese is also marketed containing 0.30 and 1 per cent of carbon. The production of ferro-manganese in the United States in 1925 was 254,900 gross tons, and the imports 78,713 gross tons. Ferro-manganese has the advantage over spiegeleisen that smaller amounts are required to obtain the required percentage in the steel, and it can be added without premelting.

Ferro-molybdenum. An alloy of molybdenum with iron, containing up to 85 per cent of molybdenum. It is

employed in the making of alloy steels for the purpose of adding molybdenum to the steel, but is being partly replaced by the use of calcium molybdate. Ferro-molybdenum is manufactured in the electric furnace from the mineral molybdenite. The American consumption of ferro-molybdenum in 1925 was 469,664 lb., containing 186,157 lb. of molybdenum. Ferro-molybdenum may contain a high percentage, up to 4 per cent, of carbon.

Ferro-phosphorus. An iron containing a high percentage of phosphorus, used for adding phosphorus to steel, chiefly in the making of tin-plate. The phosphorus in the steel is intended to prevent sticking together of the plates in annealing. Small amounts of phosphorus are also employed in open-hearth screw stock to make it free cutting. Ferro-phosphorus is made by melting phosphate rock together with the ore in making the pig iron. The phosphorus content is about 18 per cent, and is chemically combined with the iron.

Ferro-silicon. A high-silicon iron used extensively for making silicon steels, and for adding silicon to transformer cast irons. It is a product of the electric furnace, and is made from quartz or silica, iron turnings, and carbon. It is produced in several grades with the silicon content varying from 12 to 75 per cent. Thirty per cent ferro-silicon contains 68 per cent of iron, and very small quantities of carbon, manganese, and such impurities as sulphur and phosphorous. Silicon forms a chemical combination with iron, and alloys with more than 30 per cent of silicon are likely to disintegrate. When the silicon content increases above 4 per cent carbon is excluded in flakes of graphite. One of the large producers manufactures two grades, 15 per cent and 45 per cent, while another standardizes on 15, 50, 75 and 90 per cent. It is marketed in lump or crushed forms. Silicon-metal is a name given to the alloys of highest silicon content. Ferro-silicon is employed to add small quantities of silicon to iron and steel, the silicon making the steel hard and resistant to corrosion.

Ferro-silicon is also used for the insoluble anodes in the electrolytic plants for the reduction of copper from its ores.

Ferro-silicon aluminum. An alloy containing about 45 per cent of silicon, 12 to 15 per cent of aluminum, and the remainder iron. It is used as a deoxidizer in steel making in the electric furnace. It is usually put in the ladle, and is more effective than aluminum for deoxidizing steels. It is also employed for adding silicon to aluminum casting alloys.

Ferro-titanium. An alloy of titanium with iron used as a purifying agent for steel due to the great affinity of titanium for oxygen and nitrogen at temperatures above 800 deg. C. The ferro-carbon-titanium is made in the electric furnace, and the carbon free alloy is made by reduction with aluminum. The value of the alloy is as a cleanser, and little or no titanium remains in the steel. Alloys containing more than 18 per cent of titanium are difficult to use owing to their high melting point. The process of making ferro-carbon-titanium consists in charging the electric furnace with finely pulverized titaniferous iron ore mixed with charcoal and heating at a temperature above 3,500 deg. F. This yields an alloy containing 15 to 18 per cent of titanium, 5 to 8 per cent of carbon, and the balance iron.

Ferro-tungsten. An alloy of iron and tungsten containing 65 to 75 per cent of tungsten, or sometimes more. It is used for mixing with steel to form tungsten and other alloy steels. Ferro-tungsten is one of the oldest iron alloys, having been made first by Berthier in 1834. It is now made in the electric furnace by reduction of the oxide WO_3, and iron.

Ferrous sulphate. Also called iron sulphate, copperas, or green vitriol, and is a green crystalline substance of the composition $FeSO_4 \cdot 7H_2O$. It is produced by the action of dilute acid or iron, and is a by-product of the galvanizing and tinning industries, being recovered from the pickling

baths. It is the most important iron salt in the ink industry, and is used to give permanent color to the inks. It is also employed in water purification, as a disinfectant, in "rouge" for polishing, and as a pigment in other industries. The specific gravity is 1.898, melting point 64 deg. C., and it is soluble in water but insoluble in alcohol. On exposure to the air it becomes yellowish, or "rusty" owing to the formation of a basic iron sulphate.

Ferro-vanadium. An alloy of the metal vanadium with iron, employed in the steel industry for adding vanadium to the steel, and as a powerful deoxidizer. It is made by reduction with carbon in the electric furnace of ferrous vanadate, calcium vanadate, or the oxides. There are various grades of the alloy, with vanadium contents up to 40 per cent, and carbon up to 6 per cent. Some grades contain silicon up to 15 per cent. For use in steel, the carbon content should be very low.

Fiberloid. The trade name of pyroxylin plastic marketed in the form of rods, tubes, and in standard sheets 20 × 50 in. in size, with thicknesses from 0.005 in. up. It is a pyroxylin hardened with camphor, and containing a fibrous filling material. It is a product of the Fiberloid Corporation, Indian Orchard, Mass. See Pyroxylin plastics.

Fiber silk. A name sometimes applied in the retail trade to rayon. It is of indefinite meaning, and refers to any artificial silk. See Rayon.

Fibrofelt. The trade name of a pressed flexible board of matted flax and rye-straw fibers used as an insulating material for walls. It is marketed in strips from 8 to 10 ft. in length, and 32 and 36 in. wide. The thicknesses are 1/16 to 1 in. The 5/16-in. boards weight 55 lb. per 100 ft., and the 1 in. boards weigh 115 lb. per 100 ft. It is a product of the Union Fiber Company, Inc., Winona, Minn.

Fibrotex. The trade name of a plastic compound used for waterproofing and resurfacing roofs, or as a filler for

cracks in construction work. It is composed essentially of mastic gums and asbestos fiber, and is claimed not to dry hard and brittle. It is marketed in cans and barrels, and is a product of the Truscon Laboratories, Detroit.

Fibrox. A soft fibrous material used as a heat insulator. It is covered by U. S. patent 1094352, and is a silicon oxycarbide, SiCO, prepared by melting silicon with a catalytic agent such as calcium fluoride in a crucible and allowing carbon monoxide and carbon dioxide to diffuse through the containing vessel. The specific gravity of the fibres is 1.8 to 2.2, but the apparent specific gravity of the material is about 0.003, about 99 per cent of the space being occupied by air. It is claimed to be a highly efficient heat insulator.

Filter sand. A natural sand employed for filtration, especially of water. The commercial production of filter sand in the United States is about 100,000 tons annually. The largest producers of specially prepared filter sand are New Jersey, Illinois, and Minnesota. Filter sand is prepared from ocean beaches, lake deposits and sand banks. It must be of fairly uniform size, free from clay and organic matter, and chemically pure. It is always washed and dried before shipment. Filter sand grain sizes are specified in millimeters. The most commonly specified have effective sizes from 0.35 to 0.65 mm. Very fine sand clogs the filter, and is objectionable. The maximum content of combined carbonates is usually specified as not more than 2 per cent.

Finishing steel. A class of tool steel containing from 1.15 to 1.25 per cent of carbon, from 1.50 to 2.00 of tungsten, and small amounts of tungsten and vanadium, also known as tap steel. Another group of finishing steels contains from 1.30 to 1.40 per cent of carbon, 2 to 5 per cent of tungsten, and small amounts of chromium and vanadium. These steels are quenched in water to develop extreme hardness. Due to the tungsten content the hardness is retained better than with carbon tool steels, and they hold a better cutting

edge. They are deep hardening, and have low resistance to shock. The steels are used for tools for taking finishing cuts at high speeds. They are also used for taps, dies, broaches, reamers, and other cutting tools.

Firebrick. A term employed to distinguish bricks used in fire places, furnace linings, or flues, where ordinary bricks are likely to melt or crack. In the restricted sense firebricks are understood to be made of fireclay or refractory clays rich in alumina and silica, but low in ferrous oxide, lime, and alkalies. The clay is never used alone, as it is likely to contract excessively and crack, but is mixed with other clays, sand, or graphite. Firebricks are made in various shapes and sizes, and are usually white or buff in color. Some other materials used in making firebricks are: Chromite, bauxite, diatomaceous earth, and magnesite. Artificial materials are usually silicon carbide, and aluminum oxide. Common firebricks from natural fireclays will melt at from 2,800 to 3,100 deg. F. Chromite bricks will withstand temperatures up to 3,700 deg. F., and magnesia brick up to 3,900 deg. F. Silicon carbide without a clay binder will withstand temperatures above 4,000 deg. Fahrenheit.

Fish glue. A by-product of the fish oil industry. It is separated from the oil in the vats, and is a jelly formed by the solution of the hides of the fish. It is used widely as an industrial glue.

Fish oil. An oil obtained from the fat of the cod, herring, sardine, salmon, and sprat by boiling the fish and skimming the oil from the surface. The oil is of pale or brownish color and has an offensive odor. The specific gravity is about 0.930. It is of the non-drying class, and used for lubricants, leather dressing, and glues. It is sometimes bleached white. Japan fish oil consists of mixtures of the oils of Japanese sardines and herrings. The American production of fish oil is 13,000,000 gal. annually, together with 20,000 tons of fish meal and scrap used for cattle feed and

fertilizer. Besides its use in lubricating oils, fish oil is employed for oil baths in heat-treating steels. See also Herring oil, Whale oil, Menhaden oil, Blackfish oil, Salmon oil, Sardine oil.

Flax. A fiber obtained from the flax, or linseed, plant, *Linum usitatissimum*, and used for making the fabrics known as linens, and for thread, twine, and cordage. Flax consists of the "bast" fibers, or those in the layer underneath the outer bark, and they are of very fine texture. The fiber is valued because of its beauty, strength, and durability. It is finer than cotton, and the fibers of commercial flax are usually about 20 in. in length. The largest producers are: Russia, Belgium, Holland, Italy, Ireland, France, and Egypt. Some flax is grown in the United States, especially in Michigan and Minnesota. The plants that are grown for the seeds, linseed, yield a poor fiber, and are not employed to produce flax. The plants are pulled up by the roots, "retted," or partially decayed, scraped, and the fibers combed out. The fibers are bleached in the sun. For the best European flax the preparation is entirely by hand. See also New Zealand flax.

Flint. An opaque variety of chalcedony which shows no visible structure. Thin plates of flint are pale yellow and translucent. Flint contains from 96 to 99 per cent silica, and usually owes its dark color to organic material. It becomes white when calcined, and of a dull luster. Under the microscope flint is finely crystalline. It is extremely hard and brittle, and has a specific gravity of 2.6. Flint was the prehistoric utility material for tools, and was later used with steel for giving sparks on percussion. It is still employed for this purpose in automatic lighters. Flint is used for building purposes, and in pottery and glass manufacture, and in crushed form as an abrasive. It is widely distributed in all parts of the world. Flint paper for abrasive purposes contains crushed flint in grades from 20, to 240 mesh. It is usually coated on 70 or 80-lb. paper and sold in 9 by 11-in. sheets, or in rolls. See also Sandpaper.

Flooring plaster. Plaster used for flooring, and made by the calcination of pure gypsum at a temperature of about 400 deg. F. The gypsum dehydrates at about 190 deg. F. Flooring plaster is entirely free from water, and is generally finely ground. It gives a hard and durable surface if properly protected from water during the setting. It is often mixed with sand to make the floor less expensive. A cubic foot of hardened plaster weighs 120 lb. Hard-finishing plasters contain some alum. See Mack's cement, and Keene's cement.

Fluorite. Also called fluorspar. A common mineral used as a flux in the making of steel, in making opalescent glass, and in enamelling utensils. It is also used as a binder for vitreous abrasive wheels. It is also employed in the preparation of hydrofluoric acid. It is a calcium fluoride, CaF_2, and occurs in crystals or massive granular. The specific gravity is 3.18, and the hardness 4. The most common colors are light green, yellow, bluish-green, rose, or brown. It has a vitreous luster. Fluorite is found in quantity in southern Illinois and in Kentucky. It is a better flux than limestone, making a fluid slag, and freeing the iron of sulphur and phosphorus. It is used with limestone in the melting of iron ore. The usual grades are gravel smaller than ½ inch.

Flux. A substance added to a refractory material to aid in its fusion, such as lime for melting iron, or resins for melting non-ferrous metals. A secondary action of a flux, which is also sometimes the primary reason for its employment, is as a reducing agent to oxidize or decompose impurities and carry them off as slags or as gases. The materials used to cover baths of molten metals, such as charcoal, may thus be considered as fluxes, as also are the materials used to prevent oxidization in soldering. A soldering flux, such as zinc chloride, may also act as a cleaning agent to prepare the surface. Fluxes for melting iron are lime, limestone, dolomite, or fluorspar. For brass, bronze, or soft white metals, resins or oils are used, while

the covering flux may be powdered charcoal, salt, or borax. Cryolite is used as a flux for aluminum, and for glass. The standard flux for use on steel sheet for making tin plate is palm oil. "White flux" is a mixture of sodium nitrate and sodium nitrite. It is a strong oxidizer and is used for welding. Borax is also used as a welding flux. Fluxes, especially compounded for specific uses, are on the market under many trade names.

Fluxing stone. A common term for the limestone or dolomite used in the melting of iron. Approximately 900 lb. of limestone are employed for every long ton of pig iron produced in the blast furnace, and the consumption of limestone for this purpose is enormous. If iron ore were reduced without a basic flux the silica and alumina would unite with the iron oxides to form double silicates of iron and alumina, and there would be a heavy loss of iron. With the addition of limestone the silica and alumina, having a stronger affinity for the lime and magnesia, form compounds which contain very little iron. These compounds form a liquid slag which floats on the surface of the molten iron and can be removed readily. The flux also removes sulphur and phosphorus from the iron. Some iron ores are "self-fluxing," that is, they contain sufficient lime carbonate to be self fluxing. Lime is more effective as flux than limestone, but is too expensive. The action of the blast furnace is to first convert the limestone into lime. Limestones for use as flux must be fairly pure, or additional slag and compounds will be found. See also Dolomite, and Fluorite.

Fontainemoreau bronze. This alloy is in no respects a bronze, but is a zinc-copper alloy in which the zinc predominates. The usual composition is from 90 to 92 per cent of zinc, 7 to 8 per cent of copper, sometimes 1 per cent of iron or 1 per cent of lead, or both. At the present time the alloy has little commercial value, but was widely employed previous to the use of aluminum alloys. The addition of the copper to the zinc breaks up the large

crystals, but the alloys are very weak, and have no elongation. The addition of iron and lead makes little or no improvement. The addition of aluminum to the alloy greatly increases its strength.

Forging brass. Any alloy of copper and zinc, employed for the die forging of mechanical parts. The alloys may also contain tin to make them harder, and lead for free-cutting qualities. They often also contain iron in considerable quantities, although iron is considered detrimental to ordinary drawing brass. The best forging range of mixtures, as given by the Mueller Brass Company, Port Huron, Mich. is: Copper 56 to 63 per cent; lead, 0 to 3 per cent; tin 0 to 3 per cent; zinc, the remainder. With the copper content below 56 per cent the brass is brittle, and mixtures from 63 to 86 per cent are hard on dies. Alloys containing 87 to 99 per cent copper are sometimes forged. The forging temperature is 1,250 to 1,300 deg. F. Higher temperatures cause bad oxidation. Forging brass is melted in electric furnaces and run into billets, after which it is extruded into rods under hydraulic pressure. Brass forgings made in smooth steel dies are tough and compact, and need no polishing, being simply pickled in a nitric acid bath to bring out the color. See also Brass.

Formaldehyde. A colorless, poisonous gas, of the composition HCOH, with a boiling point of −21 deg. C. It is very soluble in water, and is marketed as a 40 per cent solution under the name of formalin. Formalin usually contains, however, only 37 or 38 per cent of formaldehyde. It is a clear, colorless liquid with a specific gravity of 1.075 to 1.081. Formalin is obtained by oxidation from methyl alcohol. It is one of the best disinfecting agents, and is also used in making molding compounds. Another use is as a reducing agent in the silvering of mirrors. Combined with phenol and cresol it forms varnishes and synthetic resins for molding, and as substitutes for hard rubber and amber. Commercial products of this nature are Bakelite and Condensite.

Franklinite. An ore of the metals zinc and manganese. It is approximately of the composition $(FeZnMn)O \cdot (FeMn)_2O_3$, but shows wide variation in the proportions of the different elements. It is found in the zinc deposits of New Jersey. The zinc is converted into zinc white, and the residue is smelted to form spiegeleisen. The mineral franklinite occurs in massive granular structure with a metallic luster and an iron-black color.

Frary metal. The trade name of a lead-calcium-barium alloy used for bearings in place of babbitt. It is a product of the United Lead Company. It contains about 1.5 per cent of calcium and barium. Frary metal is made by an electrolytic process. The anodes are 9-in. graphite electrodes, and the cathode consists of a molten bath of lead, 2 tons per cell. The electrolyte is a fused solution of barium and calcium chlorides. The cells operate at 10 volts and 2,000 amperes, and it takes about 2 days to bring the composition of lead up to the required percentage of Ca and Ba, after which the alloy is tapped. The metal is very hard, and when cold has a bell-like ring.

Fuel oil. Distillates of petroleum oils employed in Diesel engines and in oil-burning furnaces. True fuel oils are the heavier hydrocarbons in kerosene. See Kerosene. In some cases, however, only the light oils, naphtha and gasoline, are distilled from petroleum, and the residue is used as fuel oil.

Fuller's earth. A soft, opaque clay with a greasy feel, much used as a filtering medium in clarifying and bleaching fats, greases, mineral and vegetable oils. It absorbs the basic colors in organic compounds. It is also employed as a pigment filler, and a substitute for talcum powder. In medicine it is used as an antidote for alkaloid poisoning. It was formerly much used by textile manufacturers as a "fuller" for woolen cloth, cleansing it by absorbing oil and grease. It is a hydrated compound of silica and alumina with sometimes ferric oxide. The color is greenish-

brown or greenish-gray. Unlike clay, it falls to powder in water. It is marketed dried, or dried and ground. The American production of fuller's earth in 1926 was 234,152 short tons.

Fumigant. A liquid, powder, or gas used in fumigating buildings or ships for killing burrowing animals. The fumigants consist of calcium cyanide, hydrocyanic acid gas, carbon disulphide, sulphur dioxide, or carbon monoxide. Fumigants are distinct from repellents, which are used for driving out animals or insects. These consist of compounds containing naphthalene, ammonia, coal-tar products, or lime-sulphur solutions.

Furfural. Also known as furfuraldehyde. It is a colorless liquid with an aromatic odor, employed for making synthetic resins for molding purposes. The composition is $C_4H_3O{\cdot}CHO$. The specific gravity is 1.159, and boiling point is 161 deg. C. On exposure it turns black and gradually decomposes. It is soluble in 11 parts of water. It can be prepared by treating pentoses with dilute acid. It is made from cornstalks, corncobs, straw, oat husks, and peanut husks by treating under pressure and distilling. Corncobs yield about 6 per cent. Furfural also finds use as a preservative and as a disinfectant. Furfural when heated with aniline at 150 deg. C. forms an insoluble black substance which is used as an enamel. Furfural is also used for blackening other molding resins.

Furfural-acetone resin. A brilliant, transparent, elastic molding resin formed by the reaction of furfural and acetone in the presence of caustic soda or potash. It is used for the molding of many kinds of articles, and can be dyed to any color. A somewhat similar product, under the name of furfuracetone, is covered by U. S. patent 1,587,269, and is used for making photographic films.

Furfural-phenol resin. A synthetic molding resin made by the reaction of furfural and phenol in the presence of an acid. The substance formed is an infusible, insoluble

resin of brown or black color. The dark color, however, gives this resin a more limited application than other phenol resins.

Fusel oil. Also called fermentation amyl alcohol. A colorless liquid of the composition $CH_3 \cdot CH_3CH(CH)_2 \cdot OH$, having a specific gravity of 0.810, and boiling point of 130 deg. C., and employed as a solvent for synthetic resins and lacquers. It is soluble in water, ethyl alcohol, and in ether. Fusel alcohol is obtained as a by-product in the fermentation of organic materials in the manufacture of ethyl alcohol.

Fusible metal. A group of alloys having a melting point below the temperature of boiling water, 100 deg. C. They are used chiefly as solders or binding plugs in automatic sprinkler systems. They consist generally of mixtures of lead, tin, and bismuth, but some of very low melting point also contain cadmium. The general rule is that an alloy of two metals has a melting point lower than either of its constituents. By adding still other low fusing metals to the alloy a product is obtained that has the required low melting point. A fusible metal with a melting point of 60 deg. C. is composed of 26.5 per cent of lead, 13.5 per cent of tin, 50 per cent of bismuth, and 10 per cent of cadmium. A melting point of 75 deg. C. is obtained with 27.5 per cent of lead, 10 per cent of tin, 27 per cent of bismuth, and 34.5 per cent of cadmium. Other fusible metals are: Lead 32 per cent, tin 18, bismuth 50, melting point 85 deg. C.; lead 25 per cent, tin 25 per cent, bismuth 50 per cent, melting point 94 deg. C. Various alloys of this kind are known under trade names such as Rose's alloy, Wood's alloy, and Homberg's alloy.

Fustic. The wood of the tree *Chlorophora tinctoria*, of the West Indies and tropical America. It has a yellow color, is very hard, and has a fine, open grain. The weight is about 41 lb. per cu. ft. The wood is used for cabinet making, but its chief use has been as a dyewood. It pro-

duces the dyestuffs Morin and Maclurin. "Young fustic" is the wood of a species of sumach.

Galena. The chief ore of the metal lead, and from which most commercial lead is produced. It is a lead sulphide, PbS, containing theoretically 86.6 per cent of lead. The ore, however, contains many other minerals and usually carries only 4 to 11 per cent of lead. It is concentrated by wet gravity methods to contain 50 to 80 per cent of lead. Galena has a bright metallic luster, streaked gray, a specific gravity of about 7.5, and a hardness of 2.75. It frequently contains silver, and sometimes cadmium, bismuth, and copper. The lead is obtained from the concentrated ore by blast-roasting and smelting, and the other metals removed by oxidation and skimming. Southern Missouri is the chief source of galena lead production.

Gallium. An elementary metal, symbol Ga, discovered in 1875 by Lecoq de Boisbaudran. It is soft and easily cut. Its melting point is 87 deg. F., softening when held in the hand. It is soluble in hydrochloric and nitric acids. Gallium is found in small quantities associated with zinc ores, but has not been obtained in commercial quantities. Its boiling point is between 1,500 and 2,000 deg. C., and it is valued for high-temperature thermometers.

Galvanized iron. A general name for steel and iron sheets coated with zinc by dipping in a bath of the molten metal. The most common sheets are of low-carbon steel. After rolling, the sheets are annealed, pickled, cold rolled to polish them, and then dipped. Galvanized sheets are resistant to corrosion, and are used for roofing and sheathing. They usually come in lengths of 6, 7, and 8 ft., and widths of 24, 26, 28, 32, 34, and 36 in. The thickness is by gage sizes, usually from No. 14 to 30. Galvanized sheets are either plain or corrugated. Wire is also "galvanized" by dipping in molten zinc, and is marketed plain or twisted.

Gambier. An extract obtained from the leaves of the shrubs *Uncaria dacyoneuro*, *U. gambier* and other species,

of India. It is quite similar to catechu. The liquid water-extract contains 25 per cent of tannin, and the cube gambier 35 per cent. The latter is in small pieces. It also comes as a brown, solid mass in large blocks of 200 lb. each. Gambier is employed in tanning and dyeing, giving yellow colors.

Gangaw. The Burmese name applied to the wood of the tree *Mesua ferrea*, sometimes called iron-wood. The wood comes in large logs, is rose-red in color, and is extremely hard. It is also tough, and has a fine grain, taking a very good polish. The weight is about 70 lb. per cu. ft. The tree is native to India and Burma. It is used for tool handles and in construction.

Ganisand. The trade name of a refractory ganister used for lining and repairing furnaces. Its fusing point is given as 3,250 deg. F. It is a product of the Quigley Furnace Specialties Company, Inc., New York. It is marketed in three grades based on the sizes of the aggregate, and is packed in 125-lb. bags.

Ganister. An English refractory material, which is essentially silica with lime as a binder. A typical analysis is 94.6 per cent of SiO_2, 1.4 per cent of Al_2O_3, 0.9 per cent of Fe_2O_3, 0.48 of CaO, 0.16 of MgO, and 2.54 per cent of alkalies and water. The name ganister is also applied to a mixture of about 85 per cent of silica and 15 per cent of clay. Ganister is used chiefly for furnace linings.

Garnet. A large group of minerals used for abrasives, for bearing pivots in watches, and also as gem stones. Garnets are aluminum tri-silicates of lime, magnesia, ferrous oxide, and other substances together with manganese oxide or chromic oxide. The general formula of garnets is $R_3R'_2(SiO_4)_3$, in which R is Ca, Mg, Mn, or Fe oxides, and R′ is Al, Cr, or Fe oxide. There are thus six general types of garnets. The hardness range is from 6½ to 7½, and the specific gravity is 3.4 to 4.3. The color is most often red, but it may be brown, yellow, green, or black. Garnets occur in a wide variety of rocks in various parts of the world.

Owing to the cheapness of the common varieties, and the consequent depreciation of the name garnet, the stones that are marketed as gems are always sold under other names. "Cape ruby," from South Africa is a red garnet, and the fine "Uralian emerald" is also a garnet. See also Abrasive garnet.

Garnierite. An important ore of nickel, found near Noumea, New Caledonia. About 10 per cent of the world's supply of nickel comes from these deposits. Garnierite is a nickel silicate of approximately the formula H_2NiSiO_4. It is amorphous and earthy, with a specific gravity of 2.2 to 2.8, and a hardness of 3 to 4. The color is apple-green or whitish. The ore contains about 5 per cent of nickel, and is smelted in blast furnaces with gypsum, producing a matte containing about 45 per cent of nickel. This is shipped to Europe, where it is reduced with charcoal and refined.

Gas oil. A brownish, oily liquid obtained in the distillation of petroleum and shale oils, and used for enriching coal gas for illuminating purposes, and also used as a fuel in heavy oil engines. It has the odor of kerosene, and a specific gravity of about 0.850. It is obtained from petroleum after the kerosene fraction, above 300 deg. C. It possesses high calorific power, over 18,000 B.t.u., and is free from ash and asphaltum. It contains about 85 per cent of carbon, 13 of hydrogen, and 2 of oxygen.

Gasoline. A product obtained by the fractional distillation of petroleum oils. It is a hydrocarbon between C_6H_{14} and $C_{10}H_{22}$, and distills off between the temperatures 69 and 174 deg. C. It is a colorless liquid with specific gravity between 0.066 and 0.747, and is employed chiefly as a motor fuel. Commercial gasoline has an upper level as high as 225 deg., and an average specific gravity of 0.75. "High-test" gasoline comes within the correct limits. Five gallons of crude petroleum will usually yield about 1 gallon of gasoline.

Gear bronze. An indefinite name for any bronze used for casting gears and worm wheels. It usually indicates a phosphor bronze of high-tensile strength, chill cast. A typical bronze of this character contains 88.5 per cent copper, 11 tin, 0.25 lead, and 0.25 per cent of phosphorous. The chief value of the phosphorus is as a deoxidizer. This bronze when cast has a tensile strength up to 40,000 lb. per sq. in., an elongation up to 10 per cent in 2 in., and a Brinell hardness from 70 to 80, or up to 90 when chill cast. The weight is 0.305 lb. per cu. inch.

Gedge's metal. A brass containing some iron. A similar alloy was used in the making of old Chinese cannon. It is claimed to be malleable at a red heat, and can be rolled or drawn into wire. The presence of iron in brasses is usually considered as detrimental for ordinary uses, but improves the brass for forging. Gedge's metal contains 60 per cent of copper, 38.2 per cent of zinc, and 1.8 per cent of iron.

Genelite. A spongy bronze having approximately 40 per cent by volume of graphite mechanically mixed with it and uniformly distributed throughout its mass. The porosity due to the graphite allows the metal to absorb about 3 per cent of its weight of oil, or 20 per cent by volume. Genelite is used as a bearing metal, and for piston pins, crankpins, and sealing rings for engines. It is especially valuable for bearings of vertical shafts where it is difficult to lubricate. Genelite has little strength, and bearings made from it must be large and well supported. It is a product of the General Electric Company.

Germanite. A mineral of a dark reddish-gray color containing no less than 20 elements, but chiefly valuable as a source of the rare metal germanium. The mineral contains about 45 per cent copper, 30 per cent sulphur, 9 per cent germanium, 5 per cent iron, 4 of arsenic, 3 of zinc, and smaller amounts of lead, gallium, silica, titanium, tungsten, molybdenum, manganese, nickel, cobalt, cad-

mum, magnesium, and carbon. The approximate formula is $10Cu_2S_4GeS_2 \cdot As_2S_3$. It is found at Tsumeb, South West Africa.

Germanium. An extremely rare elementary found in argyrodite, zinc blend, sphalerite, teallite, tantalite, and certain other minerals. The chemical symbol is Ge. It is obtained by reduction from its oxides with carbon in a current of hydrogen. It has a specific gravity of 5.47, and a melting point of about 900 deg. Centigrade.

German silver. A general trade name for a group of copper-nickel-zinc alloys with a wide variety of commercial uses. The color varies from white to nickel, and also to yellowish. The metal does not tarnish or corrode easily, and is used for springs and contact points in electrical work. It is also employed as a base metal for plated silverware. German silver is graded according to its nickel content. "Extra white metal," the highest grade, contains 50 per cent of copper, 30 per cent of nickel, and 20 of zinc, while the "fifths," for plated goods contain 57 per cent of copper, 7 of nickel, and 36 of zinc. See Nickel silver.

Gilding metal. A brass alloy containing 95 to 97 per cent of copper and 5 to 3 per cent of zinc, and employed chiefly for the manufacture of cheap jewelry. It has a reddish-gold color. It is also used for making bullet jackets, where a slightly harder metal than copper is required. It is a standard product of the brass mills.

Gilsonite. A natural asphalt found in Colorado and Utah, and used for roofing, paving, in hard-rubber insulation, in bituminous waterproof paints, and in japans. It is a lustrous, black, brittle mass, having a specific gravity of about 1.070. It is soluble in alcohol, turpentine, and mineral spirits, but not in water. In quantity it comes crude in 200-lb. bags, or in barrels. Elaterite is a similar asphalt found in Utah, and used chiefly for marine and acid-resisting paints. Grahamite is another asphalt found

in large deposits in Oklahoma. It is used for insulation and molding materials, and in paints. Manjak is a variety of asphalt from Barbados and Trinidad, and used for insulation, protective and acid-resisting paints. See also Asphalt.

Glass. The amorphous solid substance formed by the fusion of silica and a basic oxide. Silica has the rare power of existing in the amorphous state when solid, and crystallization can be prevented by cooling slowly. Glass is composed of acid oxides such as silica, boric oxide, and phosphoric anhydride, and basic oxides including Na_2O and K_2O, and oxides of barium, manganese, magnesium, and other elements. Glass was made in the most ancient times by fusing sand with an alkali, and the Egyptians were famous glass makers. The important properties of glass are its transparency, its rigidity at ordinary temperatures, and its capacity for plastic working at elevated temperatures. Glass is frequently colored with metallic oxides. The composition of glass varies with the use for which it is intended. See Crown glass, Plate glass, Optical glass. Glass is cast, pressed, or blown, and cast glass is often "cut" by grinding. Glasses for "cut glass" contain lead to give them a crystalline brilliancy. "Bohemian glass" is a potash-lime glass with a content of 72 per cent of silica. It grinds and polishes well. Common glass, known as bottle glass, is composed of silica, with soda and lime. Its green color is due to the presence of iron. Common window glass is usually blown into cylindrical form, and then flattened into sheets. It is likely to be wavy or bowed in the flattening. Pure quartz glass is entirely transparent to ultra violet light rays. Hydrofluoric acid readily attacks glass, and can be used for etching it. The density of glass varies from 2.25 for borate glass to 6.33 for the heaviest lead and barium glasses.

Glass sand. Sands employed in glass making. They are all screened, and usually washed to remove fine grains and organic matter. The grain standards of the American Ceramic Society specify that all should pass through

a No. 20 screen, between 40 and 60 per cent should remain on a No. 40 screen, between 30 and 40 per cent should remain on a No. 60 screen, between 10 and 20 per cent on a No. 100 screen, and not more than 5 per cent should pass through a No. 100 screen. Sand for first quality optical glass should contain 99.8 per cent of SiO_2, a maximum of 0.1 per cent of Al_2O_3 and 0.02 per cent of Fe_2O_3. Third quality flint glass may contain only 95 per cent of SiO_2, and as high as 4 per cent of Al_2O_3. Only in the eighth and ninth quality amber glasses is the content of Fe_2O_3 permitted to reach 1 per cent. The commercial production of glass sand in the United States in 1924 was 2,170,000 short tons. Potters' sand is usually a good grade of glass sand of uniform grain employed for packing to keep the ware apart.

Glue. A cementing material usually made from impure gelatin from the clippings of animal hoofs and hides, or from the skins and heads of fish, or from bones. Good grades of glue are semi-transparent, free from spots and cloudiness, and are not very brittle at ordinary temperatures. The stiffening quality of glue depends upon the evaporation of water, and it will not bind in cold weather. Albumen glues are made from blood or from casein, and these are much used for fastening plywood. However, they do not have the strength of the best grades of animal glue. Marine glue is an insoluble glue made from solutions of resins, including rubber. A typical marine glue contains 1 part of rubber, 2 of shellac, and 3 of pitch. The rubber is first dissolved in carbon bisulphide. Dextrin is also used as a light glue, but is more in the class of mucilage. Animal glue has been used since ancient times. It is now employed for cementing and bonding a great variety of materials. Its chief disadvantage is that it is soluble in water, and will not withstand dampness. Hide glues are graded in first, second, third, and fourth cookings, and the best glues have high viscosity. Fish glues do not form gelatine well, and are usually made into liquid glues. The latter are also made by treating other glues with a weak acid. Bone

glues are usually amber colored, while hide and sinew glues are light or dark brown. The hide glues are the strongest. Pungent odors indicate defective glue. In use glues should not be boiled. The melting temperature is about 140 deg. F. White lead is sometimes added to make glue partly moisture proof. Isinglass is added to make it stronger; especially for belting cements.

Glutrin. The trade name of an oily product which is a by-product of the sulphite paper industry, and is used as a core binder in foundries. It is usually mixed with core oils. Glutrin is soluble in water, and its affinity for water is a disadvantage where standing is necessary. See Core oils.

Glycerin. Also called glycerol. A tri-hydroxy alcohol of the composition $C_3H_5(OH)_3$, forming an important constituent of oils and fats from which it is set free during saponification. Glycerin is a colorless, syrupy liquid having a sweet, burning taste. It is soluble in water and in alcohol. It is a by-product in the manufacture of soap, but is also prepared by heating fats in a current of steam, or by fermentation methods. It was made by these methods in war time when large quantities were needed for the manufacture of nitro-glycerin. Glycerin is used widely in industry. It does not evaporate easily, and is used in articles which require to be kept from drying, such as in stamping inks. It has a low freezing point, 17 deg. C., and a high boiling point, 290 deg. C., and is thus valuable as an anti-freeze liquid for automobile radiators. It is also used in making some synthetic molding resins, such as Glyptal. With litharge it makes a cement used in plumbing. Double distilled glycerin has a specific gravity of 1.260. Glycerin is marketed crude or distilled.

Glyptal. The trade name of a synthetic resin claimed to have high binding powers, and of being capable of withstanding higher temperatures, 300 deg. C., than the phenol resins. It is employed as a binder for mica insulation in

electrical work, and also as a molding compound for various articles. It is made from glycerin and phthalic acid or phthalic anhydride, under U. S. patent 1,108,329, and is a product of the General Electric Company. The molding compound is covered by patent 1,634,969. The ordinary Glyptal resin is dissolved in a high-boiling-point solvent such as benzyl benzoate, heated to a temperature of 210 to 290 deg. C., and the changed resin precipitated by pouring into benzol. The white mass after drying is ground into a powder which is the molding compound. It cures rapidly after molding into an insoluble solid, which is hard and tough, and is non-corrosive.

Goethite. A minor ore of iron of the composition $Fe_2O_3 \cdot H_2O$, containing theoretically 62.9 per cent of iron. It occurs usually massive, of a specific gravity of 4.37, and hardness of 5 to 5.5. The color is yellowish-brown to dark-brown. Goethite is found in England and in the Lake Superior hematite deposits.

Gohi iron. The trade name of a pure open-hearth iron containing not over 0.125 per cent of carbon, manganese, sulphur, phosphorus, silicon, or other impurities. It contains a very small percentage of copper to add to its rust-resistant qualities. It is a product of the Newport Rolling Mill Company, Newport, Ky. Gohi iron is claimed to be uniform in quality, and to have exceptional rust-resisting qualities. It is used especially for sheet-metal construction work.

Gold. An elementary metal, chemical symbol Au, known since the most ancient times as one of the precious metals. It is so chemically inactive that it is mostly found in the native state. It is found widely distributed in all parts of the world. It is employed chiefly for coinage, ornaments, jewelry, and for gilding. Gold is extracted by crushing the ores and catching the metal with quicksilver. The metal is yellow in color, soft, and is the most malleable of all the metals. It can be beaten into extremely

thin sheets. A gram of gold can be beaten into leaf covering 6 sq. ft., and only 0.0000033 in. thick, or into a wire 1.5 miles in length. Cast gold has a tensile strength of 20,000 lb. per sq. in., and drawn gold wire 27,000 lb. per sq. in. The specific gravity is 19.32, and the melting point is 1,943 deg. F. It is not attached by nitric, hydrochloric, or sulphuric acids, but is dissolved by aqua regia, or by a solution of azoimide. On account of its softness gold is almost always alloyed with other metals, usually copper, silver, or nickel, and graded on a basis of degrees of fineness in 1,000 parts, or on the basis of carat gold value, pure gold being 24 carats. The world's production of gold in 1926 amounted to a value of $388,500,000, of which the Transvaal produced 54 per cent, and the United States 11 per cent. See also White gold, Red gold, Green gold.

Granite. A coarse-grained, igneous rock having an even texture, and consisting largely of quartz and feldspar with often small amounts of mica and other materials. Granite is very hard, compact, and takes a fine polish, showing the beauty of the crystals. It is the most important building stone, and is also used as an ornamental stone. It is extremely durable. The colors are usually reddish, greenish, or gray. The weight is 170 lb. per cu. ft., the specific gravity 2.72, and the crushing strength is 15,000 lb. per sq. in. The most notable granite quarries are in northern New England.

Graphite. Also called plumbago. A natural variety of elemental carbon having a grayish-black color and a metallic tinge. It occurs in two forms, foliated and amorphous. It is a good conductor of heat and of electricity. Foliated graphite is used principally for crucibles and lubricants, and amorphous for lead pencils, foundry facings, electric brush carbons, and paint pigments. It is infusible, and is a good conductor of heat and electricity. The hardness of graphite is 1 to 2, sometimes less than 1, and it has a decidedly greasy feel. It is a valuable lubricant, especially mixed with grease. It is not affected by high

temperatures, and is sometimes mixed with molten bronze or babbitt to be used as bearing metals. Graphite is found in large deposits in Mexico, India, Ceylon, and in the Southern States of the United States. The production of graphite in the United States in 1927 was 5,200 short tons, equally divided between amorphous and crystalline varieties. The imports in 1927 amounted to 17,400 short tons, the amorphous coming largely from Mexico, the crystalline from Ceylon, and the flake from Madagascar. Graphite is also made artificially in the electric furnace as a residue in the decomposition of a carbide.

Gravel. A natural material composed of small, usually smooth, rounded stones or pebbles. It is distinguished from sand by the size of the grain, which is usually above ¼ in., but gravel may contain large stones up to 3 in. in diameter, and some sand. It will also contain pieces of shale, sandstone, and other rock materials. Gravel is used in making building cements and concrete or for a loose paving material. Commercial gravel is washed to remove the clay and organic matter, and screened. "Pea gravel" is screened gravel between ¼ and ½ in. in diameter. It is used for surfacing with asphalt, or for roofing. Gravel is sold by the cubic yard or by the ton, and is shipped by weight. "Bank-run" gravel, with both large and small material, weighs about 3,000 lb. per cu. yd. See also Sand, and Crushed stone.

Green gold. The name of a gold-silver-copper alloy employed in making jewelry. Green gold is graded on a basis of carats, the grades varying from 14 to 18, pure gold being 24. The 18-carat green gold contains 18 parts of gold and 6 parts of silver, with no copper. The 15-carat grade contains 15 parts of gold, 8 of silver, and 1 of copper, while the 14 carat grade contains 14 parts of gold, 8¼ of silver, and 1¾ of copper. The higher the gold content, the deeper is the greenish shade.

Greenockite. An ore of the metal cadmium. It is a sulphide of cadmium, CdS, and contains theoretically 77.7

per cent of cadmium. It occurs in powdery, earthy form, of a yellow color. The hardness is 3, and the specific gravity is 4.9. It is found in Scotland, Central Europe, and in the zinc ores of Missouri and Arkansas.

Grefco. The trade name of a high-temperature cement used for cupola linings. It is composed mainly of chromite, and is claimed to have a fusing point of from 3,400 to 3,500 deg. F. It is a product of the General Refractories Company, Philadelphia.

Grindstones. Sandstones employed for grinding purposes. Grindstones are generally employed for the sharpening of edge tools, and do not compete with the hard emery, aluminum oxide, and silicon carbide abrasive wheels which are run at high speeds for rapid cutting. Grindstones are quarried from the sandstone deposits and made into wheels usually ranging from 1 ft. in diameter to about 6 ft. in diameter, and up to 16 in. in thickness. They are always operated at low speeds because of their inability to withstand centrifugal stresses. The grades vary from coarse to fine. Good grindstones have sharp grains, without an excess of cementing material that will cause the stone to glaze in grinding. The texture must also be uniform so that the wheel will wear evenly. See also Sandstone, and Pulpstones.

Guaiac gum. Also called guaiacum. The gum resin of the guaiacum, or lignum vitae trees, *Guaiacum officinale*, *G. sanctum*, and other species, of tropical America. It is used in varnishes, although its chief use is in medicine as a stimulant, for skin diseases, and for catarrh. It contains guaiacic acid and guaiacol. The resin is of a greenish-brown color, with a brilliant fracture. It gives a burning sensation in the mouth. It is soluble in alcohol, ether, and in alkalies.

Guayule. A perennial plant grown in northern Mexico and southern California as a source of a rubber substitute. The plants are small. They mature in 5 years, and are

cut down and contain in the dry state 14 to 16 per cent of latex. The plant is crushed and pulverized in mills, and the rubber extracted by flotation. The rubber has a high tensile strength, is readily vulcanized like ordinary rubber, and is of good quality, although softer than true rubber. The industry is chiefly in the hands of the Intercontinental Rubber Company. The production of guayule rubber in 1927 was 8,100,000 pounds.

Gum. A name given in the United States to the wood of the tree *Liquidambar styraciflua*, of the United States and Mexico. It is also called satin walnut, red gum, and sweet gum. In England it is known as California red gum, and hazel pine. The wood has a reddish-brown color, is soft with a fine, close grain, and weighs about 40 lb. per cu. ft. It is used chiefly for furniture, but has various other industrial uses. The timber is cut mostly in the Southern States, especially in Louisiana, Mississippi, and Arkansas. The production of gum in the United States in 1925 was 1,100,648,000 board feet.

Gum arabic. Also called acacia gum. The gum exudation of the small tree *Acacia arabica*, and various other species of acacia trees of southern Asia, Africa, and the East Indies. It is used for adhesives, inks, and as a binding and filling material in the textile and other industries. The trees are wounded and the sap allowed to run out, forming in yellowish, transparent lumps. It is soluble in water, but insoluble in alcohol. It is also marketed in powder, and is packed in 100-kilogram bags. About 85 per cent of the gum arabic comes from the Sudan.

Gumwood. The wood of several species of eucalyptus trees native to Australia and Tasmania, but now grown in many parts of the world. The wood is used in construction and for inferior furniture. The blue gum is *Eucalyptus globulus*, which attains a height of 300 ft. The wood is a pale-straw color, is hard and tough. It has a twisted grain and shrinks and warps easily, but is very durable. The

weight is about 50 lb. per cu. ft. Salmon gum, from *Eucalyptus salmonophloria*, has a salmon-red color, is dense and hard, and has a fine, open grain. It is claimed to be superior to all the eucalyptus woods, and has a great variety of uses. The weight is about 60 lb. per cu. ft. Red gum, from *E. calophylla*, has a yellowish-red color, is strong, tough, and weighs about 45 lb. per cu. ft. The grain is fine, but has gum veins intersecting. Various other species of gumwood are marketed under the names of York gum, jarrah, blackbutt, tuart, gum, and Australian red mahogany.

Gun iron. A name sometimes applied to a pure grade of cast iron made in the air furnace. The iron is low in sulphur and in total carbon, and has a more uniform structure and finer grain than ordinary blast-furnace iron. It gets its name from the fact that it was formerly used for casting cannon.

Gunite. The trade name of a "graphitic steel," produced by The Gunite Corporation, Rockford, Ill., and used especially for automotive brake drums. It is also employed for cams, rolls, worms, and machine parts where resistance to sliding wear is required. It is made by a special process and consists of a matrix of iron with the carbon in even flakes throughout the metal. Its tensile strength is 35,000 lb. per sq. in., and the Brinell hardness is about 200. It is close grained, and tough. It can be hardened to about 477 Brinell by heating to a temperature of 1,600 deg. F. and quenching in water or oil. The compressive strength of the hardened metal is 225,000 lb. per sq. in., and tensile strength 18,100 lb. per sq. inch.

Gun metal. The common name for a casting bronze containing on an average 88 per cent of copper, 10 of tin and 2 of zinc. It casts and machines well, and is suitable for making steam and hydraulic castings, valves, and gears. It has a tensile strength of 32,000 to 45,000 lb. per sq. in., and an elongation of 15 to 30 per cent in 2 in., with reduction of area of 12 to 25 per cent. The specific gravity is 8.7

and the weight is 0.315 lb. per cu. in. The Brinell hardness varies from 65 to 74. This alloy is the same as the "G bronze" of the U. S. Navy department. See also Modified gun metal.

Gunny. A very coarse sackcloth woven of jute, and used for sacks and for baling. The weave is irregular, and the color is usually a dirty brown. The center of the gunny weaving industry is Bengal, but it is also made extensively in Scotland from Bengal jute. See also Burlap.

Gunpowder. Also known as black powder. An explosive extensively used for blasting purposes. It was introduced into Europe prior to 1250, and was the only propellant used in guns until 1870. It is now superseded for military uses by smokeless powders which do not leave a residue nor erode the gun to such an extent. Black powder also has the disadvantage of deteriorating under atmospheric conditions. Gunpowder is a mechanical mixture of potassium nitrate (saltpeter), charcoal, and sulphur, in the proportions of 75, 15, and 10. More saltpeter increases the rate of burning, and additional charcoal decreases the rate. A typical slow-burning powder for propelling rockets contains 54 per cent of saltpeter, 13.4 of sulphur, and 32.6 of charcoal. Commercial black powder comes in grains of graded sizes, and is glazed with graphite. The grain sizes are known as: Pebble powder, large-grain, fine-grain, sporting powder, mining powder, Spanish spherical powder, and cocoa powder. The potential energy of gunpowder is estimated at 340,000 kilogram-meters per kilogram of powder, or about 500 ft.-tons per lb. The actual gun efficiency of the powder, however, is from $\frac{1}{10}$ to $\frac{1}{50}$ of this amount. A temperature of about 2,100 deg. C. is produced by the explosion of gunpowder. See also White gunpowder.

Gurjun balsam. Also known as wood oil, and sometimes incorrectly called East Indian copaiba. An oleo-resin obtained from various species of the *Dipterocarpus* tree, about 50 varieties of which grow in India, Burma, Ceylon,

and the Malay Peninsula. It is employed in varnishes, and as an adulterant of copaiba. The Burmese trees form two groups yielding products known as "kanyin" and "in." Kanyin oils are brown in color, while the in oils are whitish and heavier. Gurjun balsam of commerce may consist of either or both of these products. Commercial gurjun oil is obtained by steam distillation of the balsam, and has a specific gravity of 0.900 to 0.930. It is soluble in alcohol.

Gutta percha. A gum obtained by boiling the sap of several species of trees of the order *Sapotaceae,* native to Borneo, New Guinea, and the Malay Peninsula. It is a grayish-white substance, very pliable, but not elastic like rubber. It is bleached with a solution of caustic soda. Gutta percha, like rubber, will vulcanize with sulphur, and form a very hard material. It is used for mixing with rubber, but its chief use is in the covering of insulated electric cables. It is also employed like balata for impregnating driving belts, and for washers and valve seats, and in cements. Gutta percha is imported under many trade names, which seem to have no particular significance.

Gypsum. A common mineral consisting of hydrated calcium sulphate, $CaSO_4 \cdot 2H_2O$, used chiefly for making "plaster of Paris." The color is naturally white, but it is sometimes gray, yellow, red, or brown due to impurities. When gypsum is burned for several hours at 500 deg. C. it forms a slow-setting plaster which gives a hard surface, and is used for floors. A crystalline variety, known as selenite, occurs in transparent crystals, and usually splits easily in thin laminations. A marble-like variety is called alabaster, and is employed in ornamental work. Gypsum is also used as a filler in paints, and for making incombustible wall boards. The specific gravity of gypsum is 2.28 to 2.33, and the hardness 1.5 to 2. See Plaster of Paris, and Keene's cement.

Hackia. Sometimes called iron-wood, and also erroneously named lignum vitae. The wood of the tree *Ixora*

ferrea, of the West Indies and tropical South America. It is brown in color, and has a coarse, open grain. It is very hard and tough. The weight is about 55 lb. per cu. ft. Hackia is employed for making various parts where hardness is required. It is also used for furniture.

Hafnium. An elementary metal discovered in 1923 by Coster and Hevesy of Copenhagen. Its name is derived from Hafnia, the Latin name for Copenhagen. The metal is present on the earth in about the same amount as copper, but has as yet no commercial application. The atomic weight is 178.6. All zirconium minerals contain several per cent of hafnium, but it is difficult to separate the two metals, and all zirconium preparations contain some of it.

Hair. The fibrous covering of the skins of various animals, and used for making coarse fabrics and for stuffing purposes. It is distinguished from wool in having no epidermal scales, and cannot be spun readily, although certain hairs, such as camel hair, are noted for great softness, and can be made into fine fabrics. Horse hair is from the manes and tails, and is used for making haircloth, which is employed as a covering material. Cattle hair is taken from dead animals. It is used as a binder in plaster and cements, and is also used to blend with coarse wools.

Hair cloth. A stiff, wiry fabric with a cotton or linen warp, and a filling of horsehair. It is elastic and firm, and is used as a stiffening or interlining material. The colors are black, gray, or white. The fabric is difficult to weave, and disintegrates easily, as the hairs cannot be made into a single strand, and must be woven separately. "Press cloth," used for filtering oils, is made from goat hair and from human hair, the latter coming from the Orient.

Hair felt. A felt made entirely of hair, and usually in heavy thicknesses. It is used as an insulating material for refrigerator cars, or for the protection of piping in walls.

It is marketed in rolls. The usual thickness is from ¼ to 2 in., and the widths 36 and 72 inches.

Hammer scale. A common name for the sesqui-oxide of iron formed in the hot-rolling or forging of steel and iron. It is used for de-carbonizing steel by packing the steel articles in the scale and raising to a high temperature. It is also employed for annealing steel by burying the hot steel in a bed of the scale and allowing it to cool gradually. Hammer scale has the composition Fe_3O_4. It is hard, having a hardness of 5.5 to 6.5 on the Moh scale, or about the same hardness as abrasive garnet. It is obtained in quantity from drop-forge shops or rolling mills.

Hard bronze. The shop name for a casting bronze used for bushings, nuts, and other working parts of machines. The composition used by the General Motors Corporation for its "general hard bronze" is 88 per cent of copper, 2 of lead, 7 of tin, and 3 of zinc. It makes clean, dense castings, and machines well. It has an ultimate strength of 30,000 lb. per sq. in., and an elongation of 12 per cent in 2 in. The "special hard bronze" used by the same company contains 88 per cent of copper, 10 of tin, and 2 of zinc. It is very tough and difficult to machine. It is used for gears, and for parts working under heavy pressures.

Haveg. The trade name of a German wood substitute used for molding various parts, and for containers for acids. It is made of a phenol resin mixed with asbestos fibers, and is a product of the Sauereschulzgesellschaft, Berlin. It will resist organic acids, and sulphuric and hydrofluoric acids, and will withstand temperatures up to 200 deg. C., but is dissolved in alkalies and in nitric acid.

Heat insulators. Materials employed for retarding the passage of heat rays. All material substances offer some resistance to the passage of heat, but the term refers to materials having high resistance to heat rays. Heat insulators may be such materials as felt, fiber boards, cork, or mineral wool, used for insulating partitions in buildings

for protection against moderate temperatures, or they may be highly refractory substances such as chromite, magnesia, fireclay, asbestos, used for insulating boilers or furnaces against very high temperatures. Asbestos sheathing, felt pads, and special fiber boards are often marketed under trade names. High-heat insulators are usually refractories, but are used for the specific purpose of stopping passage of the heat waves, rather than to resist fusion as in the case of a melting-pot material. The low-temperature heat insulators may also be employed to retain the cold in refrigerating systems. See also Refractories.

Heat-resistant alloys. Nickel-chromium-iron alloys containing usually from 5 to 80 per cent of nickel, 13 to 25 per cent of chromium, and the balance iron. However, some of these may contain little nickel and chromium, and have silicon, manganese, or other elements. They are used for making boxes employed for the heat-treatment of steel parts, and also for parts for furnaces, or for machine parts that are exposed to continual heating. The alloys will also resist oxidation, and the action of many acids. Some classes will withstand temperatures up to 2,200 deg. F. without scaling. Typical heat-resisting alloys are: Ascoloy, Atha's 2,600 alloy, Nichrome, Alumel, Chromel, and Delhi rustless iron.

Helium. A colorless, odorless, elementary gas having a specific gravity of 0.1368. Because of its extreme lightness and non-inflammable quality it is valued for filling balloons, but it is also employed in electric lamps and radio tubes. The liquefying point is about −269 deg. C. Helium is obtained from atmospheric nitrogen or from natural gas.

Hematite. An abundant and important ore of iron. It is an iron sesquioxide, Fe_2O_3, containing theoretically 70 per cent of iron. The color is usually various shades of reddish-brown, and the structure is usually earthy. The variety known as kidney ore is columnar with a fibrous

appearance, while specular hematite has a brilliant luster with foliated structure. The hardness is 5.5 to 6.5, and the specific gravity 4.8 to 5.3. It is a widely distributed mineral, found in granites and red sandstones. The chief iron ores of the United States consist of hematite, the most important centering about Lake Superior and in Alabama. See also Iron ore.

Hemlock. The wood of the coniferous tree *Tsuga mertensiana*, of the west coast of the United States and Canada. This species is also called mountain hemlock, and the commercial shipments of "hemlock" may also include "eastern hemlock," or "hemlock spruce," *Tsuga canadensis*, "western hemlock," *T. heterophylla*, and "Carolina hemlock," *T. caroliniana*. The wood is yellowish-brown in color, is soft and brittle, coarse grained, and not very durable. The weight is about 35 lb. per cu. ft. It is used largely as a rough lumber for outside construction work. The American production of hemlock in 1925 was 2,140,000,000 board feet, about half of which was cut in Washington. Hemlock-bark extract is obtained from the bark of the eastern hemlock, and is an important tanning material for leather. The liquid extract contains 25 per cent of tannin, and the powder contains 50 per cent.

Hemp. A fiber widely used as a material for cordage, rope, and sacking. It comes from the stalk of the plant *Cannabis sativa*, grown chiefly in southern Russia, the Mediterranean countries, and Asia, but also cultivated in the United States. The fiber is longer than that of the flax plant, being up to 75 in., but is much coarser, and is not suitable for fine fabrics. It is also more difficult to bleach. It is stronger, more glossy, and more durable than cotton. It is very resistant to water. The finest fibers are claimed to be from the Italian hemp. The plant also contains a toxic alkaloid, and in India the stalks are eaten for the exhilerating and narcotic effect. The dried flowers and dried plant are mixed with tobacco in Turkey and some other countries, and smoked for the narcotic effect.

Hemp-seed oil is made by pressing the seeds. It has a specific gravity of about 0.926, iodine value of 148, and is used in paints and varnishes. See also Manila hemp, and Sisal hemp.

Herring oil. A fish oil obtained by extraction from several species of herring, the commercial oils coming usually from the Norwegian herring, *Clupea harengus*, or from the Japanese herring, *Clupea pallasi*. It is employed as a quenching oil in heat-treating, either alone or mixed with other oils. It is not suitable as a drying oil for paints or varnishes as it does not give an elastic skin. The oil contains a number of fatty acids, chiefly linolic, oleic, and palmitic. The specific gravity is 0.920 to 0.930. The iodine value is as high as 140, and the saponification value 191. Herring oil can be made clear and odorless by hydrogenation.

Hexalin. An organic solvent of the composition $C_6H_{12}O$, made by the hydrogenation of phenol, using nickel as a catalyst. It is an excellent solvent for fats, oils, and resins, and is also used as a substitute for turpentine. Hexalin is a solid with a specific gravity of 0.947, melting point 25 deg. C., and boiling point 161 deg. C. It is soluble in 28 parts of cold water, and can be mixed with alcohol in all proportions.

Hexamine. A white, crystalline powder used chiefly for the manufacture of synthetic resins in place of formalin and its sodium hydroxide catalyst. It is formed by the action of formaldehyde and ammonia. It has the formula $(CH_2)_6N_4$, and is very stable when dry. It is readily soluble in water and in alcohol. It is also known as Formin, Cystogen, Aminoform, and Cystamine.

Hexa-nitro-diphenylamine. A high explosive employed by the Germans in torpedoes because of its high shattering effect. It was sometimes mixed with 30 to 40 per cent of dinitro-toluene, which makes a more fusible product and detonates with great violence. It is a yellow powder of the

composition $C_6H_5 \cdot NH \cdot C_6H_4(NO_2)_3$. Its melting point is 242 deg. C., at which point it then decomposes. It is made from picryl chloride and aniline. It is highly poisonous, causing blisters, inflammation, and painful wounds.

Hickory. The wood of the tree *Hicoria ovata*, and several other species of the walnut order. It is highly prized as a wood for ax, pick, and other tool handles, and also for wheel spokes, carriage shafts, and golf clubs. The color varies from white to dark-brownish. It has a fine, even, and straight grain, and is very tough and elastic. The weight is 45 to 52 lb. per cu. ft. Hickory is native to the United States and Canada. The chief producing States are Arkansas, Louisianna, Mississippi, Tennessee, and Kentucky. The 1925 production in the United States was 79,293,000 board feet. For handle manufacture the white wood or the "red" wood are considered equal in physical properties, and both possess the smooth "feel" required for handles. After cutting and rough turning the handles are ground on sanded belts, and dried for 60 hours at a temperature of 125 deg. F. They are then waxed.

Hides. A commercial name generally signifying the skins of full-grown beef cattle. Kips and calfskins are the names given to the hides of the younger animals. Hides of other animals besides the beef catle, *Bos taurus*, are usually designated with the name of the animal, as horsehide. Hides are shipped in immense quantities from Argentina, Uruguay, and other pastoral countries, and made into leather. They are shipped either dried or salted, and are distinguished by numerous grades depending upon the class of animal, method of skinning, and the preparation. Packing-house hides, well skinned, and packed in brine, are the best. The poorest grade is the country hide which has been taken off by inept knives and then dried in the sun.

High brass. The mill name for the most common of the commercial brasses marketed in sheets and strips. It usually contains 65 per cent of copper, and 35 per cent of

zinc. It is used for drawing and forming, and also for spinning. In the hard tempers it is employed for parts made by blanking, bending and forming. The "high brass bar" used by the Westinghouse Electric & Manufacturing Company for automatic screw stock contains 60 to 63 per cent of copper, 2.25 to 3.25 of lead, and not over 0.15 per cent of iron. It is free cutting and yet tough enough to bend cold 120 deg. without fracture. See Brass.

High-lead bronze. A bronze alloy used for machinery bearings for high speeds and average pressures. It is usually deoxidized with phosphorus, and may contain some excess of this element. When chill cast the alloy is very hard. A typical alloy of this character is Alloy No. 6 of William H. Barr, Inc., Buffalo, N. Y. It contains an average of 78 per cent of copper, 8 of tin, and 14 of lead. This alloy has a tensile strength of 28,000 to 32,000 lb. per sq. in., elongation of 12 to 16 per cent, compression under 100,000 lb. per sq. in. of 32 to 35 per cent, and Brinell hardness of 54 to 70. The weight is 0.335 lb. per cu. inch. See also Bronze.

High-speed brass. A name sometimes applied in the machine shop to brass containing a small percentage of lead. It is "free cutting," and can be machined easily at higher speeds than common brass. See Leaded brass, and Ledrite brass.

High-speed steel. The general name of a class of alloy steels that have the property of red-hardness, and find their chief use for metal-cutting tools. High-speed steels are made in either the crucible or electric furnace. There are two general classes, according to the tungsten content. These are the 14 and the 18 per cent tungsten. Still another class, the super high-speed steels, contain 2 per cent more tungsten, and some molybdenum and cobalt. The range of high-speed steels is from 13 to 19 per cent of tungsten, 0.60 to 0.77 per cent of carbon, 3 to 4

per cent of chromium, and from 0.25 to 2.25 per cent of vanadium. In addition, the super class contain about 0.75 per cent of molybdenum, and 5 per cent of cobalt. The low-tungsten steels are not used extensively in the United States, but are used in England. The property of red-hardness in high-speed steels is developed by heating above 2,100 deg. F. Tools made of high-speed steel will cut mild steel at rates up to 150 ft. per min. working at a red heat. High-speed steels are hardened by preheating to about 1,500 deg. F., then heating rapidly to a temperature of from 2,250 to 2,400 deg. F. They are drawn at 1,000 to 1,150 deg. F. as soon after quenching as possible. The steels containing cobalt are hardened at temperatures up to 2,450 deg. F., and will stand up in tools under very heavy cuts. High-speed steel can be annealed by packing in lime and heating for 2 hr. at 1,550 deg. F., then holding at 1,350 deg. F. for 6 hr., and allowing to cool slowly in the furnace. High-speed steels are marketed in rods, bars, and flats of many shapes and sizes.

High-test cast iron. A shop term for cast iron that has been super-heated in the melting for pouring, and then the castings given a treatment that produces a tough white iron. The pouring temperature is up to 3,000 deg. F. The iron is poured into chilling molds, and the castings are annealed at 1,475 to 1,550 deg. F. The resulting iron resembles malleable iron, and is much cheaper to produce. Such an iron containing 2.70 per cent of total carbon, 1.55 of silicon, 1.0 of manganese, 0.04 of phosphorus, and 0.025 of sulphur, showed 2.3 per cent of temper carbon, and had a tensile strength of about 57,000 lb. per sq. in. See Cast iron.

Hipernick. The trade name of a high-permeability nickel alloy, used chiefly in making the cores of audio-frequency transformers and electric current transformers. It has a maximum magnetic permeability under suitable heat-treatment of about 50 times that of pure iron. It contains about 50 per cent of nickel and 50 per cent of iron.

Holly. The wood of the tree *Ilex aquifolium*, and several other species of *Ilex*, or holly tree, native to Europe. It is valued as a wood for inlaying on account of its white color and very fine, close grain. It also takes stain well. It is rather hard, and the weight is 47 lb. per cu. foot.

Homberg's alloy. A "fusible plug" alloy of low melting point used for sprinkler plugs, and where an easily fused metal is required. The melting point is about 251 deg. F. It contains 3 parts of lead, 3 of tin, and 3 of bismuth.

Horn. The excrescent growth, or horns, from the head of certain animals, especially beef cattle. Horn is used for making handles for knives, and for various other articles. The quality depends largely upon the class of animal from which it comes. The horns occur on the head in pairs, and are hollow, growing on a core of bone. In manufacturing, the horns are split by saws, soaked for a long period to render them flexible, and then flattened under hydraulic pressure into slabs.

Hornbeam The wood of the tree *Carpinus betulus*, of the United States and Europe. It is very strong and tough and has many mechanical uses for implements, gears, mallets, and structural parts. It was formerly much used for "cog wheels," and friction drums. The wood is yellowish, with a close, fine grain. The weight is 52 lb. per cu. ft. It is also very flexible.

Hot-die steels. A class of tool steels employed for making forging dies that must be used in contact with red-hot metal. They will resist shock and retain their hardness and will wear well at elevated temperatures. Two types of these steels are in general use. The first is a chromium steel containing 3.5 to 4.0 per cent of chromium, and 0.80 to 0.90 per cent of carbon. The second is a tungsten steel containing 10 to 14 per cent of tungsten, 2 to 3 per cent of chromium, sometimes a small amount of vanadium, and 0.30 to 0.45 per cent of carbon. The chromium steel develops a high degree of hardness when

oil quenched. It is deep hardening, but will withstand shock. The tungsten steels are hardened in oil or in air, but require higher temperatures up to 2,100 deg. F., or higher. The hardness when quenched is lower than the chromium type, but they are superior for severe service at high heat. The impact value is also greater. The chromium type is used for dies for bolt and header machines. The tungsten steel is more expensive. It is used for dies, for hot punching, and for hot brass forging.

Hyblum. A trade name for a ductile aluminum alloy especially adapted for sheet-metal work. It is made under U. S. patent No. 1,579,481. The alloy contains copper, nickel, chromium and some other elements. It is made in four grades. The color is white, and it takes a fine polish. The specific gravity is 2.73, and the electric conductivity is about half that of copper. Grade A can be heat-treated and has a tensile strength up to 40,000 lb. per sq. in. It is a product of the Sheet Aluminum Corporation, Jackson, Michigan.

Hybnickel. The trade name of a group of heat-resistant alloys made by Victor Hybinette, The Pusey and Jones Corporation, Wilmington, Del. Alloy "A" withstands temperatures up to 2,100 deg. F., and is used for carburizing boxes, hearth plates, and furnace conveyor parts. Grade B is a "high-rigidity" alloy for temperatures up to 1,800 deg. F. Other grades are C, D, R, and S. The latter two are especially made for acid resistance. See Heat-resistant alloys.

Hydraulic bronze. The shop name for any casting bronze or brass used for pump parts, cocks, and valves. A recommended high-pressure hydraulic bronze is given as 72.5 per cent of copper, 19.25 per cent of zinc, 1.75 of tin, and 6.5 of lead. This alloy is in reality a leaded brass. It casts well, and machines freely. See also Steam bronze.

Hydraulic lime. When lime contains other substances, such as silica and alumina, and is hydrated, it has the power of setting and hardening under water. It is a class

of natural cement. Limestone with more than 10 per cent of silica will give a hydraulic lime on calcination. This lime will show no action for about 15 min. when slaked with water, and then will take upwards of 14 days to slake. It will set under water in 15 to 20 days. Some French limestones contain 20 to 22 per cent of silica, and 2 per cent of alumina, and hydraulic cement is widely made in France and Belgium by burning these limestones. The lumps of slaked lime are finely ground, and are known as Grappier cement. Some of the white cements sold under trade names, such as Le Farge, belong to this class.

Hydrochloric acid. Also called muriatic acid. An inorganic acid used for the pickling and cleaning of metal parts, and also for a great variety of other industrial applications. It is a water solution of hydrogen chloride, HCl, and is a colorless or yellowish fuming liquid, with pungent, poisonous fumes. The specific gravity of the gas is 1.269, the solidifying point −112 deg. C., and boiling point −83 deg. C. It is made by the action of sulphuric acid on sodium chloride, or common salt. The commercial acid is usually 20 deg. Be., and has a specific gravity of 1.16. The so-called fuming hydrochloric acid has a specific gravity of 1.19, and contains about 37 per cent of hydrogen chloride gas. Hydrochloric acid is shipped in glass carboys.

Hydrocyanic acid. A substance of the composition HCN, which is a liquid at temperatures below 26 deg. C., but is so volatile at ordinary temperatures that it is often considered as a gas. It has a wide use in the laboratory, is used in military poison gases, and as a fumigant. It is so poisonous that death may result within a few seconds after it is taken into the body. It was used as a poison by the ancient Egyptians and Romans, who obtained it by crushing and moistening peach kernels. The specific gravity is 0.697, as a gas. It is soluble in water and in alcohol, and is usually marketed in water solutions of 2 to 10 per cent. It is obtained commercially by distilling a solution of potassium cyanide and sulphuric acid.

Hydrofluoric acid. A water solution of hydrogen fluoride, HF. It is a colorless, fuming liquid, highly corrosive and caustic, and is employed for cleaning the sand from iron castings. Instead of attacking the iron like other pickling acids, it dissolves the sand from the iron. The specific gravity of the gas is 0.713, and boiling point −19 deg. C. It has a strong, pungent odor. Hydrofluoric acid is made by treating calcium fluoride or fluorspar with sulphuric acid. It is shipped in lead carboys, or in paraffin and composition bottles.

Hydrogen. A gaseous element, symbol H. It is colorless and highly inflammable. It is used in the machine shop for producing the oxy-hydrogen flame for welding, and also to produce a non-oxydizing atmosphere for the heat-treating of steels. It is also employed for the hydrogenation of oils. Hydrogen liquifies at −252 deg. C. The specific gravity is 0.0695. Its lightness makes it useful for filling balloons. It is produced easily by the electrolytic dissociation of water, or by the action of water on an alloy of magnesium and lead. It is marketed in steel cylinders at a pressure of 1,800 lb. per sq. inch.

Hydrogenated oils. Vegetable or fish oils that have been hardened or solidified by the action of hydrogen in the presence of a catalyst. Finely divided nickel is generally used for this purpose. The solidifying process is carried on to any desired extent, and these oils have a great variety of uses. For mechanical uses they are employed in cutting oils, and in place of palm oil in tinplate manufacture. The process of hydrogenation consists in converting the fatty acids, such as oleic acid, into stearic acid by adding hydrogen. Peanut oil can be thus made to the appearance, taste, and odor of hog lard, or it can be made like tallow. Cottonseed oil and peanut oil are used in large quantities in lard and butter substitutes. Hydrogenated oils have a lowered iodine value, and a higher melting point.

Hy-Glo steel. A special stainless steel containing 17 per cent of chromium, and 0.60 per cent of carbon. It has a

Brinell hardness of 196 to 600, and a tensile strength of 110,000 to 250,000 lb. per sq. in. When polished it is very resistant to corrosion, both in the annealed and in the hardened condition. It is usually furnished annealed, in bars, billets, sheets, and forgings. It is used for cutlery, tools, and machine parts. It is a product of the Latrobe Electric Steel Company.

Hytens. The trade name of an artificial aluminum oxide made in the electric furnace, and used as an abrasive. It is a product of the Precision Grinding Wheel Company, Philadelphia. See Aluminum oxide.

Hy-Ten-Sl. The trade name of a manganese bronze made by the American Manganese Bronze Company, Holmesburg, Pa. It is intended for use where a bronze of very high strength is needed. It is used for gears, rolls, high-duty bearings, and machine parts. It is furnished in castings, sheets, rods, and forgings. The castings have a tensile strength up to 105,000 lb. per sq. in., an elongation of 15 per cent in 2 in., and a Brinell hardness from 135 to 175. The weight is 0.280 lb. per cu. inch.

Illium. A complex alloy developed by Prof. S. W. Parr, and claimed to be very resistant to the action of acids and corrosive mediums. A typical analysis shows 60.65 per cent of nickel, 21.07 per cent of chromium, 6.42 of copper, 4.67 of molybdenum, 2.13 of tungsten, 1.04 of silicon, 1.09 of aluminum, 0.98 of manganese, and 0.76 of iron. It can be cast, but machines only with difficulty. A modification, known as Parr metal, contains 66.6 per cent of nickel, 18 of chromium, 8.5 of copper, 3.3 of tungsten, 2 of aluminum, 1 of manganese, 0.2 of titanium, and 0.2 of boron. It is extremely hard.

Illmenite. An ore of the metal titanium. It is an iron-black mineral having a specific gravity of about 4.5, and containing up to 52.7 per cent of titanic oxide, TiO_2, and 47.3 per cent of ferrous oxide, FeO. It occurs in workable quantities on the beaches of the southeastern part of the

United States. The illmenites of New York and Wyoming carry only 8 to 16 per cent of TiO_2. The largest use of illmenite is for making a white pigment by removing the iron oxide. It is also used for making ferro-titanium.

Inda. The trade name of a casein plastic molding material marketed in the form of sheets, rods, and tubes, for the making of a variety of articles. It is available in all colors. It is a product of the American Machine and Foundry Company, Brooklyn, N. Y. See Casein plastics.

Indene. A liquid of the composition C_9H_8, extracted from coal tar, and employed in making synthetic resins for molding compounds. It is also made by the hydrogenation of acetylene. It is a colorless liquid with a boiling point at 180 deg. C., and specific gravity of 1.002. Indene resins are classed with the cumerone resins, and are very similar in properties.

Indigo. The most valuable and important of all vegetable dyestuffs. Commercial blue indigo is obtained from the plants *Indiagofera tinctoria*, and several other species, of India and Java, and the commonest wood plant, *Isatis tinctoria*, of Europe. Indigo is apparently not present in the fresh plant. It is produced by steeping the freshly cut plants in water, and after decomposition of the glucoside indican, $C_{14}H_{17}O_6N$, the liquid is run into beating vats where the indigo separates out in flakes which are boiled and pressed into cakes. About 4 oz. of indigo are produced from 100 lb. of plants. "Indigo red," or indirubin, $C_{16}H_{10}N_2O_2$, is a crimson dyestuff obtained in the proportion of 1 to 5 per cent in the manufacture of indigo. "Indigo White" is obtained by reducing indigo red with reducing agents and an alkali. Indigo is valued for the beauty and permanence of color. It has also been made synthetically.

Indium. One of the rare metals, symbol In. It was discovered in 1863 in zinc blend. It is whiter and more silver-like than tin, and is not easily oxidized. It is soft,

ductile, and has a specific gravity of 7.36. The melting point is 155 deg. C., and boiling point 700 deg. C. Indium has as yet no industrial applications. It remains alloyed with the zinc in the reduction of the zinc from its ores.

Infrax. The trade name of a silicon carbide employed as an insulating cement in furnaces, and as a refractory brick. It is a product of the Carborundum Company, Perth Amboy, N. J. The softening point is above 3,100 deg. F., and it withstands temperature of about 2,600 deg. F. continuously. At ordinary temperatures the crushing strength of an Infrax brick is 250 lb. per sq. in. At 2,660 deg. F. it is 12.5 lb. per sq. inch.

Ingot iron. An American name for a nearly chemically pure iron made by the basic open-hearth process and highly refined, remaining in the furnace 1 to 4 hr. longer than the ordinary time, and maintaining a temperature of 2,900 to 3,100 deg. F. In England, it is referred to as mild steel, but in the United States the line between iron and steel is placed arbitrarily at about 0.15 to 0.20 per cent content of carbon. Commercial ingot iron contains as low as 0.02 per cent of carbon, so that there is now a wide gap between this product and mild steels. It is obtainable regularly in grades 99.8 to 99.9 per cent pure iron. Ingot iron is cast initially into ingots for rolling, and it is then rolled into plates or shapes and bars. It is used for construction work where a ductile, rust-resistant metal is required. The two largest uses are for plates for tanks, and in the making of galvanized sheets. The tensile strength is up to 44,000 lb. per sq. inch. Ingot iron may also be obtained in grades containing 0.25 to 0.30 per cent of copper, which is claimed to increase the corrosion resistance.

Ink. Colored liquids, or liquids containing finely divided precipitate in suspension. Aniline or other dyes are employed with metallic salts. Black writing ink ordinarily contains tanno-gallate of iron obtained by adding an infusion of nut galls to a solution of ferrous sulphate. Gum is

added to inks to keep the precipitate in solution. Sugar or glycerin is added to copying inks to retard the drying. Aniline dyes, indigo, or mixtures give the tints to both black and colored inks. Logwood, chromium, vanadium, and aniline black inks are not resistant to light. Brazil wood, cochineal, and other organic substances are also used in inks. Carbon inks are composed of lampblack with glue, gums, or solutions of gluten. Printing inks are lampblack, boneblack, barite, or other pigments suspended in linseed oil and resin oils. Invisible, or invisible-writing inks, are chemical solutions whose colors respond to the action of other chemicals applied to the writing, such as a solution of lead acetate to be developed with hydrogen sulphide, or one of gallic acid developed with an iron salt.

Insulating oils. Oils of high dielectric strength and high flash point, employed in circuit breakers, switches, transformers, and other electric apparatus. Mineral oils are used for this purpose. The flash point must be high enough to prevent fire or explosion. An oil with a flash temperature of 285 deg. F., and fire point of 310 deg. F. is considered safe. A clean, well-refined oil will have a dielectric strength of 22,000 volts, but water will decrease this amount rapidly. The presence of as low as 0.01 per cent of water in the oil is claimed to reduce the dielectric strength 35 per cent. The insulating oils, therefore, cannot be stored for long periods because of the danger of absorbing moisture. Any impurities such as acids or alkalies also detract from the strength of the oil. Insulating oils are used for cooling as well as for insulating, and the viscosity should be low enough to permit free circulation. They should not gum or form deposits.

Insulators. Any materials that retard the flow of electricity, and used to prevent the passage or escape of electric current from conductors. No materials are absolute non-conductors, and those rating lowest on the scale of conductivity are therefore the best insulators. Glass and porcelain are the most common line insulators because

they are cheap, hard, and not affected by moisture. Hard rubber, fiber, synthetic resins, slate, stone slabs, are the usual insulators for panel boards and apparatus. Mica is widely used as an insulating separator, but it must be free from traces of iron. Various varnishes, resin solutions, and asphalt mixtures are used as insulating impregnating compounds for covering wires or sheets. An important requirement of a good insulator is that it be waterproof, as any absorbed moisture will conduct electricity. Mineral oils are insulators, and are employed in control boxes. See also Heat insulators, and Sound insulators.

Insulumium. The trade name of a corrosion-resistant metal marketed by the General Electric Company. It is a steel with a surface impregnation of aluminum. It is claimed to be highly resistant to the continued action of oxygen-bearing gases at high temperatures.

Invar. The trade name of a nickel-iron alloy having a very low thermal expansivity. The expansion is so low that for measuring purposes under ordinary conditions it is generally taken as zero. It is used for the measuring guides of accurate instruments, and for parts of clocks and watches. A typical composition is: Iron 63.5 per cent, nickel 36 per cent, manganese 0.5 per cent. It melts at 2,597 deg. F. Invar is also very resistant to corrosion. The weight is 0.289 lb. per cu. inch.

Ionium. The parent substance of the metal radium. It is found in all minerals and rare earths that contain uranium and radium. It is so similar in all properties to the element thorium, that it is not possible to separate it from thorium when the two have become mixed. Ionium is obtained from uranium ores by fractioning the rare earth constituents, but the resulting preparation contains the radio-inactive thorium. Ionium gives out the alpha rays of radium, and it has some of the uses of radium.

Iridium. A grayish-white metal of extreme hardness. The chemical symbol is Ir. It is insoluble in all acids and in

aqua regia, and can be cut only with the hardest abrasives. The melting point is 4,260 deg. F. The specific gravity is 22.42. The annealed metal has a hardness of 172 Brinell. Iridium is found in its natural state in alloy with the metal osmium, known as osmi-iridium. This alloy is used chiefly for making fountain pen points. Iridium is sold by the troy ounce, a cubic inch of the metal weighing 11.82 troy ounces.

Iron. The most common of the commercial metals, comprising nearly 5 per cent of the earth's crust. It has been in use since the most remote times, but it does not occur native except in the form of meteorites. The common iron ores are magnetic pyrites, magnetite, hematite, and carbonates of iron. See Iron ores. To obtain the iron the ores must be fused to drive off the oxygen, sulphur, and impurities. The melting is done in a blast furnace directly in contact with the fuel and with limestone as a flux. The latter combines with the quartz and clay forming a slag which is readily removed. Iron is a grayish metal, which until recently was never used pure. It melts at 1,525 deg. C., and boils at 2,450 deg. C. It has a specific gravity of 7.85. All commercial iron except ingot iron and electrolytic iron contain perceptible quantities of carbon, which affects its properties. See Cast iron, Pig iron, Wrought iron, Malleable iron, Ingot iron, and Electrolytic iron. Iron containing more than 0.15 to 0.20 per cent of chemically-combined carbon is termed steel. Iron forms carbonates, chlorides, oxides, sulphides, and other compounds. It oxidizes easily under atmospheric conditions, and is also attacked by many acids. See also Steel. The "reduced iron," used in medicine and in chemistry, is a fine gray amorphous powder made by reducing iron oxide by heating in a stream of hydrogen.

Iron ores. Iron-bearing minerals from which iron can be extracted on a commercial scale and at a profit. Iron ores have been worked since prehistoric times; the mines of the Island of Elba have been worked continuously for 2,500

years. The principal iron ores of the world in the order of importance are: Hematite, magnetite, limonite, and siderite. About 93 per cent of the iron ores mined in the United States are red hematites. The districts include the Lake Superior region and northern Alabama. Brown hematites contain from 35 to 55 per cent of iron, while pure red hematite would contain 70 per cent. The hematite ores are preferred for the Bessemer process because of their freedom from phosphorus and sulphur. "Natural iron" is the percentage of iron in the ore before drying, and "dry iron" is the percentage of iron in the ore after drying at 212 deg. F. Siderite and carbonate ores are used in Great Britain, Germany, Russia and Hungary, much of which is not considered commercial in the United States. The world's supply of high-grade iron ores is placed at 30 billion tons, of which 80 per cent is located in Brazil, United States, France, Newfoundland, and Cuba, in the order named.

Iron pyrite. A common mineral sometimes mined for the gold or copper associated with it, but chiefly used for making sulphuric acid and copperas. It is an iron disulphide, FeS_2, containing 53.4 per cent of sulphur. It often occurs in crystals, also massive or granular. It is brittle, with a hardness of 6 to 6.5, and a specific gravity of 4.95 to 5.1. The color is brass-yellow. Pyrite is found in rocks of all ages associated with different minerals. It was formerly roasted to obtain the sulphur, and the residue product, known as "blue Billy" was used as an iron ore.

Iron shot. An abrasive material made by running out molten iron and spraying it with steam as it runs into a vat of water. It is employed in tumbling barrels, and also in the cutting and grinding of stones.

Ironwood. A common name for several varieties of wood, but the name is very indefinite, and is apt to refer to any exceedingly hard wood that is used for making bearings, gears, or parts of machinery. In the United States iron-wood is most likely to refer to the wood of the hackia tree,

Ixora ferrea, of the West Indies, and of tropical South America, or it may refer to the wood of the quebracho tree.

Isinglass. The common name for colorless sheets of mica used as a transparent material for stove doors. See Mica. The name is also applied to a very pure gelatine made from the dried swimming bladders of sturgeon and other fishes. "Russian isinglass" is the most valued grade, and is one of the best adhesives known. It is used in glues and cements. With hide glue it is used for "glue" for cementing leather belts, and for cementing the abrasive grains on polishing wheels.

Istle. The name sometimes applied to the stiff, hard fibers of the agave plant, used for making brushes. See Tampico. True istle fiber is obtained from istle-grass, *Bromelia sylvestris*, a tropical plant.

Ivory. The material which composes the tusks and teeth of the elephant. It is employed mostly for ornamental parts such as the keys of pianos. The color is the characteristic ivory-white, which yellows with age. The West Coast of Africa, India, and Southern Asia are the chief sources of ivory. The tusks of the hippopotamus, walrus, and other animals, as well as the fossil mammoth of Siberia, also furnish ivory, although of inferior grades. Ivory can be sawed readily, and is made into very thin veneers for various ornamental uses. It takes a fine polish. Artificial ivory is usually celluloid, although synthetic resins are also employed for the same purposes. The specific gravity of ivory is 1.87. Vegetable ivory is from the ivory nut of tropical America.

Ivory black. A charcoal derived by heating the refuse of ivory workings in closed retorts until decomposed. The charred mass is then ground very fine. It is used as a decolorizing agent, and for filtering. See also Bone black.

Ivory nut. The source of vegetable ivory, which is used for making various small articles, mostly buttons. The

ivory nut is the seed of the low spreading palm tree *Phytelephas macrocarpa*, of tropical America. The nuts grow in clusters, and are encased in shells. When the nuts are ripe they drop from the trees, and the shell is easily removed. The natives of the Darien region of Panama gather the nuts on a large scale, and the center of the shipping trade is Colon. The nuts are about 2 in. in diameter, and have a fine white color and an even texture. They can be easily worked, and are sawed and turned in the lathe. They are very susceptible to dyes, and show fine polished colors.

Japan. A name applied to black baking enamels. The same finish in other colors would not be called japan. Japan consists essentially of a pigment, a gum, a drying oil, and a reducer for ease of application. It is always baked, the usual temperature being about 375 deg. F. The general process is to drive off the solvent and fuse the gum until it is in a uniform vitreous layer. In some cases flame baking is used to burn off the solvent, and to oxidize the drying oil. Japans are used for giving a tough durable finish to machine parts, especially to such machines as the typewriter. Several coats are usually applied, the surface being carefully rubbed and polished between coats.

Japanese ash. The wood of the tree *Fraxinus mandschurica*, native to Japan, Corea, and Manchuria. Great quantities of this wood are exported. The native name is tamo. The wood is browner in color than European or American ash. The grain is close, and it is strong and tough. The weight is about 35 lb. per cu. ft. It has the same general uses as ordinary ash. The commercial shipments may also contain wood of the sen tree, which is inferior in quality.

Japan wax. A fat of the coconut-oil group used largely for adulterating beeswax. It is a vegetable fat contained between the kernel and outer skin of the berries of plants of the genus *Rhus*, which grow in Japan and are also cultivated in California. The fat, which is misnamed wax,

is extracted by steaming and pressing the berries, and is then refined by melting and pressing through cotton cloth. Japan wax is greenish-yellow, and melts at 51 deg. C. The specific gravity is about 0.975. It contains chiefly palmitic acid. The saponification value is about 220. It is sometimes adulterated with common tallow. See also Lac.

Jasper. A variety of chalcedony quartz colored blood-red with iron oxide. It is cut and polished as an ornamental building stone. "Egyptian jasper" is brown with dark zones.

Jet. A hard and compact, dense, black lignite, which can be cut and turned in the lathe, and will take a fine polish. It was formerly much used for making buttons, toys, and ornamental articles, but has been largely replaced by synthetic resins. It is found in Colorado, and in many parts of Europe.

Jute. A fiber employed very extensively for making burlap, sacks, cordage, ropes, and upholstery fabrics. It is obtained from an order of plants of India, of which *Corchorus capsularis*, is the most widely cultivated. Most of the commercial jute comes from Bengal. The plant grows in tall slender stalks like hemp, and the fiber is obtained by "retting" and cleaning. The fiber is long, soft, and lustrous, but is not as strong as hemp. It also loses its strength when damp. The crude fiber may be as long as 14 ft., but the commercial fibers are from 4 to 8 ft. The "butts," or short ends of the stalks, and the rough fibers, are used for paper stock.

Kamassi wood. The wood of the tree *Gonioma kamassi*, of South Africa, employed as a substitute for boxwood, and for the same purposes. It is also called East-London boxwood, or Cape boxwood. The wood is very hard, and has a fine dense grain, and yellow color. It has an astringent taste. It does not have the very straight grain of boxwood, and is inferior for rule and instrument use.

Kaolin. Also called China clay. A very pure form of aluminum silicate clay, of the composition $2SiO_2{\cdot}Al_2O_3{\cdot}2H_2O$, with no iron. It is used chiefly in the making of porcelain, but is also employed as a refractory material for bricks and furnace linings. Its melting point is 3,160 deg. F. It is a decomposition product of granite and feldspar, and its usual impurities are quartz sand, feldspar, and mica, which can be washed out with water. Kaolin is usually white, but inferior qualities burn to a yellow color. The Cornwall kaolin of England, and the Limoges kaolin of France are the best known. Kaolin is also employed as a pigment, particularly with zinc oxide under the name of Chinese white. It is insoluble in water. Kaolin usually occurs in clay-like masses, with a specific gravity of 2.6 to 2.63, and hardness of 2 to 2.5. The luster is generally dull.

Kapok. A silky fiber obtained from the silk-cotton tree, *Ceiba pentandra*, common in most tropical countries. It is employed for fine padding work, and is extremely light and resilient. Most of the commercial kapok comes from Java. The tree is very large, and the fiber grows in bolls, which burst when ripe. The fibers are long, white and silky, but are too brittle for spinning.

Karbolite. A Russian phenol resin employed as a molding material for electrical and mechanical parts, buttons, and novelties. It differs from certain American phenol resins in the method of manufacture. It is made in two stages, a deficiency of formaldehyde being first employed with the phenol, the resinous mass being then separated from the water formed before adding the balance of the formaldehyde. The ingredients consist of 100 parts of phenol, 30 of naphtha-sulphonic acid, and 32 parts of formaldehyde. It molds and hardens by heating to 100 deg. C. Karbolite has a resistance to electric puncture of 10,000 volts for 1 mm. thickness. It contains not more than 16 per cent of moisture.

Karolith. The trade name of a casein plastic molding material made by the Karolith Corporation, Long Island

City, N. Y. It is marketed in the form of rods, tubes, and sheets, and is used for molding a great variety of articles. See Casein plastics.

Kauri pine. A strong, durable, straight grained, yellowish wood of silky appearance, well adapted for a finish wood. The tree, *Dammara australis*, is native to the country about Auckland, New Zealand, and the New Zealand natural forest inventory of 1923 estimates 386,000,000 board feet standing. The annual cut is approximately 20,000,000 board feet. The weight of the wood is 30 to 39 lb. per cu. foot.

Kauri gum. A fossil gum dug from the ground in New Zealand, and used in varnishes, lacquers and enamels to increase the body. It is a product of kauri forests buried during some comparitively recent geological period. True kauri comes only from the *Dammara australis* forests on the northern island of New Zealand. There is no effort to extract the gum from the present kauri forests, whose wood is employed for lumber. The fossil gum has a specific gravity of 1.05, and a melting point of 182 to 232 deg. C. It is soluble in turpentine, benzol, and alcohol, but insoluble in water. It is hard and brittle, and is transparent. Kauri gives good wearing qualities to lacquer. See also Dammara.

Keene's cement. Also known as flooring plaster, or tiling plaster. A white powder which with water makes a superior kind of plaster that will set very hard and white. It is much used in the United States to imitate tiling, and in Germany for flooring. Keene's cement is made by burning gypsum at about 110 deg. C. to plaster of paris, dipping the burned lumps in a solution of alum, drying, and then burning again at from 400 to 500 deg. C. The product is then ground to powder. Heating at higher temperatures, or prolonged heating ruins the cement by causing it to lose its power of setting. Parian cement is similar to Keene's cement, except that borax is used instead of alum. Martin's cement is made with potassium carbonate instead of alum.

Kermes. A brilliant red natural dyestuff similar in color to cochineal, having a beautiful tone, and being very fast. It is one of the most ancient dyes, but is now largely replaced by cochineal and by synthetic dyestuffs. Kermes is an insect found on the kermes oak tree, *Quercus coccifera*, of Southern Europe and Asia. The body of the animal is full of a red juice, and the coloring matter, kermesic acid, $C_{18}H_{12}O_9$, is separated out in brick-red crystals. It has only about one-tenth the coloring power of cochineal.

Kermesite. An ore of the metal antimony, and also known as red antimony. It results from the partial oxidation of the mineral stibnite. The composition is Sb_2S_2O, and when pure it contains 75 per cent of antimony and 20 per cent of sulphur. It occurs in hair-like tufts, or radiating fibers of a cherry-red color and metallic luster. It has a hardness of 1 to 1.5, and a specific gravity of 4.5 The mineral is found in extensive deposits in Tuscany, Italy.

Kerosene. Known also in some localities as "coal oil." A light, oily liquid obtained in the fractional distillation of petroleum oils. It distills off after the gasoline, and between the limits of temperatures of 174 and 288 deg. C. It is a hydrocarbon of the composition $C_{10}H_{22}$ to $C_{16}H_{34}$, with a specific gravity between 0.747 and 0.775. Commercial kerosene may be as high a distillate as 325 deg. C., with a corresponding higher specific gravity up to 0.850. Kerosene is employed for illuminating and heating purposes, and as a fuel in internal combustion engines fitted with atomizers.

Kid. The commercial name for leather made from the skins of young goats. It is thin, and has a fine, close-grained texture. It is employed industrially where a fine leather is required for pads or linings. The greatest commercial use of kid, however, is in the manufacture of gloves. The leather is widely imitated in leathers made from the skins of lamb, colts, and grown goats. The best kid skins come from arid regions, and these are used for the fine French kid leather. In the glove trade the term chevreau

is used to designate the skins of the young goats that have never browsed, while chevrette refers to the skins of older kids that have eaten grass and other foods besides milk. The thin skins are sorted out and used in the glove industry.

Kieselguhr. A variety of tripoli, or infusorial earth, obtained in Germany, and employed chiefly as an absorbing material. It is also used as an abrasive, and for making imitation meerschaum. It is the absorbing material for nitro-glycerine in making dynamite. Kieselguhr is very absorbent, and will hold 75 per cent of its own weight of sulphuric acid. It is insoluble in water.

Kinite. The trade name of a wear-resisting alloy steel especially adapted for making blanking and forming dies, molding dies, cams, and cutters. It is a product of the Kinite Corporation, Milwaukee, Wis. It contains from 12.50 to 14.50 per cent of chromium, 1.50 per cent of carbon, 1.10 of molybdenum, 0.70 of cobalt, 0.55 of silicon, 0.50 of manganese, 0.40 of nickel, and the balance iron. The castings, at maximum hardness, have a tensile strength of 110,000 lb. per sq. in., and a compressive strength of 400,000 lb. per sq. in. The rolled bar, at maximum hardness, has a tensile strength of 220,000 lb. per sq. in., and a compressive strength of 420,000 lb. per sq. inch.

Kinonglas. The trade name of a German non-splintering glass used for making shields to protect against chips from machines, and for an automobile glass. The sheets are built up of two clear glass plates with a sheet of highly transparent celluloid between. The sheets are pressed mechanically to exclude air bubbles or any excess of the cement. The glass will withstand sharp blows, and when broken will break locally without splintering.

Kiri. The name of a very light weight wood from the tree *Paulownia tomentosa*, of Japan. It has a light-brown color, a coarse grain, and weighs 20 lb. per cu. ft. It is employed for making instruments, floats, and where a very light wood is required.

Kittool. A fine fiber obtained from the large leaves of the palm tree *Caryota urens*, of Ceylon and India. It is stiff, elastic, and strong, and is employed for brushes. Another species of palm, *Arenga saccharifera*, yields the arenga fiber, which is practically the same thing. The finest grades of arenga fiber resemble horsehair. Other names are used to designate brush fibers from this class of palm, such as Chinese coir, Philippine cabo negro, and gommuti fiber. Kittool is especially valued for machine brushes because of its elastic strength and resistance to water.

Kunheim metal. A pyrophoric, or sparkling, alloy used for cigarette lighters. It was covered by French patent 405,021 in 1909, and consists of hydrides of the cerium mixed metal, "Misch metal." It is produced by melting the Misch metal with magnesium and aluminum, and then heating the alloy thus made in a current of hydrogen at a temperature of about 500 deg. C. The metal contains 36 per cent of cerium, 49 per cent of lanthanum and didymium, 10 per cent of magnesium, and 1 per cent of aluminum.

Lac. A name applied to a variety of Japan wax obtained from the sumach plant, *Rhus vernici*, of Japan and Korea. It is used as a drying oil in baking "japans" and enamels, and for transparent lacquers. The name should not be confused with that of lac dye, or the lac insect which produces shellac. Japan wax is a fat of the coconut group, and is contained between the kernel and the outer skin of the berries of the *Rhus* plants, while lac is a gum exudation of the tree. See also Japan wax.

Lac-dye. An important animal dyestuff obtained from the *Tachardia lacca*, an insect which lives on the banyan and other trees of India. The female insect exudes a resinous substance which encloses the eggs. Two broods are produced annually. The twigs, with the attached resin, are sold as stick lac, and the lac dye is obtained by treating stick-lac with ammonia and stannous chloride. Lac-dye

gives about the same color as cochineal, but requires several times the quantity. A good lac-dye should be soft enough to be broken with the fingers, and to powder easily. It breaks with a resinous fracture. Lac-dye is now largely replaced by coal-tar dyes. See also Shellac.

Lace leather. A variety of leather made from the skins of porpoises, or dolphins, and used in making laces for machinery belting. The fish skins are tanned with alum and salt, and permitted to dry hard. They are then moistened with water and oiled with cod oil. The leather is very tough, pliable, and strong. It is imitated with alum-tanned and oil-treated cow hide or calfskin.

Lacquer. Originally the name for a kind of Oriental finish made with certain slow-drying varnishes, but now referring to the quick-drying finishes made from nitrocellulose, or "pyroxylin," or from cellulose acetate resins. The modern lacquers of this kind are widely used for finishing automobiles and other articles. They consist of the pyroxylin or other resin, one or more gums, a pigment, a softener, and one or more volatile solvents. Various kinds of gums are used for increasing the body and giving hardness and gloss to the finished surface. For high gloss and hardness, dammar is used. For a cheaper product elemi may be employed. Kauri is used where good wearing is required. The usual solvents are anhydrous alcohol, ethyl acetate, butyl acetate, butenol, benzol, and toluol. Softeners are such products as amyl, ethyl, and butyl phthalates. Quick drying is the chief advantage of the lacquers, but the time must be made long enough to prevent the cloudiness coming from absorbtion of moisture from cooling by the rapidity of drying. For industrial work lacquers are usually sprayed, and they then dry in about 15 minutes. Brushing lacquers are made slower in drying to prevent streaks and lumps in their application. The time of drying is controlled by arrangement of the solvents. The word lacquer is also used to describe a highly transparent varnish used to produce a thin protective film on

polished or plated metals to preserve their luster. See Nitro-cellulose, Pyroxylin, Cellulose acetate.

Lactoid. The trade name of a casein resin used as a molding material for various articles. It is a product of the British Xylonite Co., Ltd. See Casein plastics.

Lallemantia oil. A drying oil used in varnishes. It is obtained from the seeds of the *Lallemantia iberica*, a plant which grows wild in southeast Europe and in central Asia. In physical properties it resembles linseed oil.

Lampblack. A soot formed by the smudge process of burning oil, coal tar, resin, or other carbonaceous substances in an insufficient supply of air, the soot being allowed to settle on the walls or floors of the collecting chambers. Lampblack is practically pure carbon, but inferior grades may contain unburnt oil. It is used in making paints, lead pencils, metal polishes, electric brush carbons, crayons, and carbon papers. It is grayish-black in color, and is flaky and granular. One pound occupies from 200 to 230 cu. in. For use as a pigment the powder should pass through a 325-mesh screen. The paste used for japan should contain 25 per cent of lampblack and 75 of vehicle.

Lancewood. The wood of the tree *Guatteria virgata*, of the West Indies, and northern South America. It is used for fine work where toughness, uniformity, and durability are requisites, such as for measuring rods. It is used also as a substitute for boxwood. The wood is yellowish in color, and has a fine, close, smooth grain. The weight is 52 to 63 lb. per cu. ft. It is very hard and elastic.

Lanthanum. A metallic element, symbol La. It is a white metal, malleable and ductile, with specific gravity of 6.154, and melting point of 810 deg. C. It is easily soluble in acids, and oxidizes readily in the air. Practically the only use for lanthanum at the present time is in its salts for gas mantles, and in Misch metal for absorbing gas in vacuum tubes.

Larch. The wood of the coniferous tree *Larix europea*, native to Russia and some other European countries. It is of a yellowish-red color, and is the toughest and most durable of the conifers. The grain is fine, smooth, and even. The weight is about 40 lb. per cu. ft. American larch is from the Western larch tree, *Larix occidentalis*, of the Pacific Northwest, and from the tamarack tree, *Larix laricina*, of the Lake States and New England. The wood resembles the European larch, having the same weight, but is claimed to be harder and tougher. The production of American larch in 1925 was 307,000,000 board feet, most of which came from Montana and Idaho.

Lardine. The trade name for "blown" cottonseed oil, employed to mix with mineral oils for making lubricants for machinery. The cottonseed oil is maintained at a temperature of about 75 deg. C., and the air is blown through, oxidizing and thereby thickening the oil. See Blown oils.

Lard oil. A fluid oil obtained by subjecting lard to hydraulic pressure. Prime or first-grade lard oils are nearly colorless or greenish, and have little odor. Lard oil contains oleic, stearic, and palmitic acids. The commercial lard oils vary from the sweet oil to the acid and offensive-smelling brown oils. They are much used in lubricating and cutting oils, and sometimes as illuminating oils. The flash point of pure lard oil is 480 deg. F. Its saponification value is about 192. The specific gravity is 0.915. Lard oils are largely adulterated with cottonseed or blown oils. See Cutting oils.

Lautal. A German proprietary alloy containing 94 per cent of aluminum, 4 of copper, and 2 of silicon. It has the property of age-hardening, and can be artificially aged by heating in an oil bath at 130 deg. C. for about 15 hours. After casting, the metal is worked by rolling or pressing. Its tensile strength is from 54,000 to 60,000 lb. per sq. in. It is a product of the Lautal-Walzwerk, Bonn am Rhein, Germany.

Lead. A soft, heavy, bluish-gray metal with a granular structure, and a strong metallic luster. Its chemical symbol is Pb. Lead is obtained chiefly from the mineral galena. It surface-oxidizes easily, but is then very resistant to corrosion. It is soluble in nitric acid, but not in hydrochloric or sulphuric, and is one of the most stable of metals. However, it becomes hard and brittle on repeated melting due to the formation of oxides. Lead is believed to be the ultimate substance produced by the disintegration of uranium and radium. Its specific gravity is 11.38, and melting point 621 deg. F., with boiling point of 2,787 deg. F. The tensile strength is low, about 3,000 lb. per sq. in., but it is very malleable. Lead is used for pipes and cable coverings. It alloys easily with tin and other metals, and forms many commercial alloys, including solders and babbitts. It is also used for lining acid tanks, and for storage battery plates. Its compounds are used in paints, especially white lead. Twenty per cent of the lead consumed in the United States goes into storage batteries, 17 per cent for cable coverings, 22 per cent for paints, and 10 per cent for building construction. The world consumption is about 1,300,000 tons annually. Commercial lead is sold in pigs weighing 100 lb. Four grades of lead are marketed: Corroding lead, 99.93 to 99.99 per cent pure, for making white lead; chemical lead, with some silver and copper, for storage batteries, and coverings; common de-silverized lead; and soft Missouri lead. Lead and its compounds are highly poisonous. "Lead" for pencils is amorphous graphite, or graphite mixed with clays, while indelible lead for the same purpose is graphite mixed with a coal-tar dye.

Lead azide. A salt of hydrazoic acid, used as a detonator for high explosives in place of mercury fulminate. The composition is PbN_6. In large crystals it is liable to spontaneous explosion. Only one-fiftieth as much lead azide is required to explode TNT as is required of mercury fulminate.

Leaded high brass. This alloy contains approximately 65 per cent of copper, from ½ to 1½ per cent of lead, and the remainder zinc. It is one of the standard grades of brass made by the mills. It is easier to machine than high brass, but is less ductile. It does not foul the cutting or threading tools, and is used especially for cupped, drawn, or formed parts on which a clean thread must be cut. The property of free cutting is gained at the expense of its drawing capacity. The alloy used by the Westinghouse Electric & Manufacturing Company for free-cutting seamless brass tubing contains 65 to 78.5 per cent of copper, 0.35 to 0.85 per cent of lead, not over 0.10 per cent of iron, and not over 0.15 per cent of other impurities. The tube may be flattened without fracture.

Lead foil. Very thin sheet lead, or soft lead alloys, used for wrapping tobacco and other non-edible products, It is made in thicknesses from 0.006 mm. (0.00024 in.) to 0.200 mm. (0.00787 in.) the former having 10,358 sq. in. per lb., and the latter 279 sq. in. per pound.

Lead pigments. Chemical compounds of lead used in paints to give color. They are to be distinguished from the lead compounds such as lead oleate, $Pb(C_{18}H_{33}O_2)_2$, and lead resinate, used as driers for paints. White lead, $(2PbCO_3 + Pb(HO)_2)$, is the most common, and is made from $PbSO_4$ or $PbCl_2$. It is frequently adulterated with $BaSO_4$, $CaSO_4$, $BaCO_3$, chalk or clay. Chrome yellow is lead chromate, $PbCrO_4$. Orange mineral is the red oxide, Pb_3O_4, and chrome red is $(2PbO{\cdot}CrO_3)$. Madder reds, vermillionettes, and Brunswick greens are also pigments of lead. Mixtures of white lead and heavy-spar are known as Venetian white. Dutch white is composed of three parts of sulphate and one part of carbonate. All of the lead compounds are poisonous by skin absorption or when taken internally. See also White lead, Red lead, Litharge.

Leantin. The trade name of a low-tin babbitt metal containing a high percentage of lead, and used for machine

bearings where the pressure is low. It is a product of the Lumen Bearing Company, Buffalo.

Leather. The skins or hides of animals, cured by the chemical action of tannins. Leather is used for belting, gaskets, and for a great variety of other purposes. The action of tannins precipitates the protein of the hide, changes its colloidal structure, and makes it more pliable and capable of resisting decay. The process of tanning hides consists essentially in soaking the hides in solutions of the tanning material. See Tannins. This soaking may be prolonged for several months, after which the hides are washed, oiled, and rolled. Cheap leathers are tanned quickly with strong solutions of tannin, but rapid action injures the fibers and does not produce the desired chemical changes. The quality of leather depends upon the type of animal, its physical condition, the care used in taking off the hide, the method of preserving the hide before tanning, and the care used in tanning. Leather is used for a great variety of purposes, and is made from many kinds of skins, including sheep, goat, deer, alligator, seal, and shark, although the bulk of commercial leather is made from cattle hides. Animals raised in the open have hides that produce tough, close-grained leather, while breeded cattle raised for meat produce the weakest leather. But in general, packing-house hides, well skinned, and packed in brine make the best leather. Belting leather is usually made from salted hides free from cuts and scratches, and is either oak or chrome tanned. It is then "stuffed" with fish oils or tallows. Oak-tanned leather is preferred for packings and gaskets, but chrome-tanned is the best for packing for heavy-duty hydraulic cylinders or recoil mechanisms. The "artificial leather" used for making washers, clutches, and gaskets, is made from waste leather from shoe factories compressed together with a binder.

Leather fabric. Sometimes referred to as imitation leather. A substitute for upholstery leather made by applying a pyroxylin coating to a cotton fabric. The

foundation cloth may be of various weights, and may be firm or napped on the back. Leather fabrics are sold in various colors, often with designs or finishes. They are more durable than ordinary split leathers and are cheaper. They also fill the large requirement for automobile upholstery impossible to meet with the limited supplies of real leather. The usual width of the fabric is 50 inches.

Ledrite brass. A brass alloy containing a very small percentage of lead, which makes the alloy "free cutting" and capable of being cut and drilled at high speeds. It is a product of the Bridgeport Brass Company, Bridgeport, Conn. It is made in all standard shaped bars and rods from ⅛ to 3 in. in diameter.

Lepidolite. A lithia mica found in California, Massachusetts, England, Norway, and Moravia. It occurs usually in small plates, and is often with muscovite, or common mica. The composition is $KLi(Al{\cdot}2OHF)\,Al(SiO_3)_3$. The hardness is 2.5 to 4, and specific gravity 2.8. It has a pearly luster, and color pink and lilac to grayish white. It is insoluble in acids. Lepidolite is employed as a source of lithium compounds, and is also a source of the metals rubidium and caesium. See Mica.

Lethal gases. Poisonous compounds used in chemical warfare, and having deadly effects, as distinct from gases used for disabling. Lethal gases are divided into four classes: Actual poisons, which kill with little pain, such as hydrocyanic acid; asphyxiating poisons, which affect the membranes of the lungs, destroying them and allowing blood to fill the air sacks, such as phosgene, diphosgene, and chloropicrin; poisons which destroy the lining of the air passages and block the passages to the lung tissues, as mustard gas and ethyl-dichloro-arsine; and poisons which affect the nose and throat, causing great pain, headache, vomiting, pressure on the chest, sneezing, unconsciousness, and weakness, such as diphenyl-chloro-arsine. The effects of these gases are usually in proportion to the concentration

and duration of exposure. A person exposed for two minutes in a given concentration of phosgene would suffer the same as a person exposed for one minute in a concentration twice as great. The only protection against lethal gases is by covering the breathing system with masks containing activated charcoal, soda ilme, or chemical absorbents, although some sneezing gases will enter these and force their removal. See also Poison gases, Lewisite, Mustard gas, Phosgene, Diphosgene, Diphenyl-cyano-arsine.

Lewisite. A highly toxic vesicant and lethal poison used in chemical warfare. It is an almost colorless liquid of the composition $CHCl{:}CH{\cdot}AsCl_2$. Lewisite is named after its inventor W. Lee Lewis, and was popularly known as "Dew of Death." Its chemical name is chloro-vinyl-dichloro-arsine. It is made by the action of arsenic trichloride on acetylene in the presence of aluminum chloride as a catalyst. A secondary and a tertiary compound are formed at the same time, but the mixed product is employed in the crude state because of the danger of exploding on distillation. Lewisite is the strongest vesicant known, and forms most painful blisters on the skin, and its effect also passes into the system, often causing death. It also attacks the throat, nose, and lungs. It is thrown in high-explosive shells and disseminated as a mist, or "dew." See also Lethal gases.

Liberty fuel. The trade name of a motor fuel brought out during the World War. It is composed of about 65 per cent of benzol, 25 to 30 per cent of kerosene, and the remainder amyl-acetate. The initial boiling point is 175 deg. F., and it consequently will not evaporate or start as readily as gasoline. It is also likely to foul the carburetor and leave carbon deposits in the engine.

Liberty silver. A name applied in the United States during the World War to German silver, or nickel silver. The name is now practically obsolete, the newer designation "nickel silver" being preferred.

Licorice. The sweet roots of a group of plants of the order *Fabaceae.* The common licorice of Spain is *Glycyrrhiza glabra,* and of Italy, *G. echinata.* Certain other species, all native to Southern Europe, are also employed. Licorice is employed in confectionery, in medicines, in chewing tobacco, and in beverages, but industrially it is used for fire extinguishers to produce a froth to smother the fire. The dark-colored extracted juice of the roots contains a glucoside, or licorice-sugar, which will not ferment. Licorice also contains a saponin, or froth-producing substance. In fire extinguishers it is sold under various trade names.

Lignite. Also called brown coal. It is a variety of coal of more recent age than true coal, occurring in rocks of tertiary age, and is intermediate in composition between wood and coal. It is widely distributed over Europe, and occurs in many other parts of the world. Freshly-cut lignite often contains a large quantity of water, up to 40 per cent, and is sometimes also high in ash. When dried it breaks up into fine lumps and powder. Dry lignite contains 55 to 75 per cent of carbon, 10 to 30 per cent of oxygen, and 5 to 7 per cent of hydrogen. It kindles easily, but burns with a low calorific power and a smoky flame. The color varies from brown to black, and the lower grades of brown lignite show the woody structure. The "pitch coal" is brownish-black, breaks with a pitch-like fracture, and shows no woody structure. The reserves of lignite in the United States are estimated at a thousand billion tons, and form a future fuel for use in powdered form, or for distillation for oils and coal-tar products.

Lignum vitae. The wood of the guayacum trees, *guaiacum officinale,* and *G. sanctum,* of the West Indies and tropical South America, but the commercial shipments of lignum vitae are likely to contain also other species. The wood of the guayacan tree of Brazil and Paraguay is also called by this name. The best quality of the true lignum vitae is claimed to come from San Domingo. It comes in

logs up to 18 ft. long, and 12 in. in diameter. It is very hard, heavy, and tough. The color is brown to greenish-black. The grain is very fine and even. The weight is from 72 to 88 lb. per cu. ft. The wood is used in places where extreme hardness is needed, such as for pulley blocks. It is also used for rollers, handles, and furniture. In machine bearings it withstands pressures up to 4,000 lb. per sq. inch.

Lime. A calcium oxide, CaO, occurring abundantly in nature, chiefly in combination with carbon dioxide as calcium carbonate, in limestone, marble, chalk, coral, and shells. As calcium phosphate it occurs in bones and in some minerals. It is employed in mortars, cements, as a flux in steel making, a lubricant in wire drawing, and in many purifying processes, especially gas absorption. In the various mineral forms it is used for a flux in melting iron, and for building stones. Lime is obtained by heating limestone in a furnace, or kiln, to burn out the carbonic acid gas. The residue is called quicklime or caustic lime. Pure quicklime is white and amorphous or crystalline. The specific gravity is 3.08 to 3.25. Commercial limes contain above 94 per cent of calcium oxide, some calcium carbonate, and less than 0.50 per cent of magnesia. Water causes the lime to slake with much heat, leaving a white powder, $CaOH_2O$. The so-called lean limes contain magnesia, and when the content of magnesia increases to 25 per cent the lime is useless as such. Lime is marketed in lumps or ground to 20-mesh, and "mill run." Hydrated lime is made by grinding quicklime, slaking the powder with water, and sifting to a fine powder. It is easier to handle, and is a more reliable product than ordinary lime. High-grade hydrated lime will have a fineness so that 98 per cent will pass through a 100-mesh sieve, and will contain not over 2 per cent of magnesia. Some grades contain less than 0.50 per cent of magnesia, and 98 per cent pass through a 200-mesh sieve. Lime is usually marketed in barrels of about 200 lb. each, while hydrated lime comes in 100 lb. burlap sacks or 40-lb. paper bags. See also Hydraulic lime.

Limestone. A general term applied to a great variety of rocks which contain lime. Immense quantities of limestone are used as flux in the melting of iron. See fluxing stone, and dolomite. Limestone is also used as a building material, and for this purpose it is preferred in granular compact masses well bonded to form a hard, uniform stone. Limestone has the composition $CaCO_3$, and on calcination in a furnace yields lime, CaO. In its broad sense limestone includes marble, chalk, dolomite, and various other minerals containing lime. The famous Indiana limestone, used for building, is a non-crystalline rock, with aggregate, filler, and matrix all of pure carbonate of lime. The average weight is 144 lb. per cu. ft., and the crushing strength is 6,000 to 8,000 lb. per sq. in. The "mill blocks" range from 8 to 12 ft. in length, and are 3 ft. 6 in., or 4 ft. 4 in., square in section.

Limewood. The wood of the lime tree, *Tilia cordata*, native to Europe. It is pale-yellow in color, and has a fine close grain. It cuts well in all directions, and is especially suited for carving and turning. The weight is 38 lb. per cu. foot.

Limonite. Also called brown hematite, or bog-iron ore. A common ore of iron of secondary origin formed by the water solution of other iron minerals. Its composition is $2Fe_2O_3 \cdot 3H_2O$, containing theoretically 59.8 per cent of iron. It occurs earthy or in stalactitic forms of a dark brown or blackish color. The specific gravity is 3.6 to 4, and the hardness is 5. Limonite deposits are common in the Appalachian Mountains from Massachusetts to Alabama. Some varieties of limonite are used as a pigment, as yellow ocher.

Lindol. The trade name for a non-inflammable substitute for camphor for use in pyroxylin resins and as a plasticising medium in lacquers. It is tricresyl-phosphate formed from a combination of cresylic acid and phosphoric acid. It is a colorless, odorless, viscous liquid, which solidifies at -20 deg. C., and decomposes at 300 deg. C. The specific

gravity is 1.176 at 60 deg. F. It is almost insoluble in water, but miscible in all proportions with a wide range of chemical solvents. It is a product of the Celluloid Corporation, Newark, N. J.

Linen. A general name for the yarns spun from the fiber of the flax plant, or for the cloth woven from the yarn. Linen yarns and fabrics have been made from the earliest times, and the ancient Egyptian linen fabrics were of exceeding fineness. Ireland, Belgium, and France are the principal producers of linen. Linen yarns are used for the best grades of cordage, and linen fabrics are employed industrially wherever a fine, even, and strong cloth is required, such as for airplane construction. Linen fabrics are sold under a wide variety of trade names. They are graded chiefly according to the fineness of the yarns and the class of weave. "Lisle" was fomerly a fine, hard linen thread, made at Lille, France, but is now a fine, smooth yarn made of long-staple cotton spun tightly in a moist condition.

Linofelt. The trade name of a sound- and heat-insulating material used in building walls. It consists of a quilt of flax fiber between tough water-proof paper. It is marketed in rolls, and comes in thicknesses of 5/16 to 3/4 in., and in widths from 18 to 54 in. The 5/16-in. linofelt weighs 17 lb. per 100 sq. ft., and the 3/4 in. weighs 43 lb. per 100 sq. ft. It is a product of the Union Fiber Co., Inc., Winona, Minn.

Linoleum. A general trade name for a floor-covering material consisting of a fabric impregnated and covered with a compound of "blown" linseed oil, ground cork or wood, and rosin or other gum. It is rolled under great pressure, and then dyed in plain colors or printed with designs. The fabric may be of jute or other coarse material. Linoleum was invented and patented in 1863, and shortly displaced the older "Kamptulicon" floor covering, which was made of rubber, cork, rosin, and boiled oil, and was more expensive. "Battleship linoleum" is very heavy linoleum in plain colors or mosaics.

Linoxyn. A trade name for "blown" linseed oil used in mixing paints and varnishes. Linoxyn is not greasy like linseed oil, and makes a tough, elastic varnish. See Blown oils, and Linseed oil.

Linseed oil. This oil is the most common of the drying oils, and is widely used for paints and varnishes. It is obtained by pressure from the seeds of the flax plant, *Linum usitatissimum*, which is cultivated for oil purposes in Russia, India, North and South America. Argentina is the greatest producer of linseed and exports more than 1,000,000 metric tons of seed annually. The seed contains up to 40 per cent of oil. The commercial oil is hot pressed and has a bitter taste, but in Russia a cold-pressed oil is used for food purposes. Linseed oil contains about 48 per cent of linolic, and 34 per cent of linolenic acids. The specific gravity is 0.925 to 0.935. It is a yellowish oily liquid with a peculiar odor and a bland taste. It is soluble in turpentine, ether, and benzine. The best Baltic oil is used as a standard in measuring the drying power of other oils. Genuine linseed oil has an iodine value of at least 170, and the best approach 190. The oil is sometimes adulterated with rosin oil. For varnish use it is bleached by heating and forcing oxygen through it, or used as "boiled linseed oil," prepared by heating with oxidizing dryers such as the salts of lead or manganese.

Linters. The short cotton fibers that adhere to the seed after ginning. Linters removed from the cotton seed are used as a filling and padding material, and also as the raw cellulose material for the manufacture of artificial silk, smokeless powder, and pyroxylin plastics.

Litharge. The yellow monoxide of lead, PbO, produced by heating lead until it burns with a white light. It is a yellow powder used as a pigment and also in the manufacture of glass, and for fluxing and glazing of earthenware. The specific gravity is 9.375. It is produced by heating lead in a reverberatory furnace, and then grinding the lumps. See Lead pigments.

Lithium. The lightest of all metals, with an atomic weight of 6.94, and specific gravity of 0.59. It is widely distributed in nature. Lithium melts at 356 deg. F. It is unstable chemically and burns in the air. Practically the only present use of lithium is in light-sensitive control cells which depend on the change in resistance of the cell due to varying electron emission with changing light intensity.

Lithopone. Also known under various trade names: Ponolith, Beckton white, zincolith, sterling white, and others. A white pigment consisting of about 70 per cent of barium sulphate, 26 to 28 per cent of zinc sulphide, and 1 to 3 per cent of zinc oxide. It is made from barytes zinc, and sulphuric acid. Commercial lithopone is a fine-grained white powder used extensively in the manufacture of paints, and inks, and as a filler in rubber goods. For paints the powder should pass through a 325-mesh screen. The ground paste should contain 76 to 80 per cent of pigment and 20 to 24 of linseed oil. It is also used as a filler in oilcloth, and linoleum.

Litmus. A vegetable dyestuff allied to orchil. It is prepared from various varieties of the lichen, *Variolaria*, by allowing them to ferment in the presence of ammonia and potassium carbonate. When completely fermented the mass assumes a blue color, and is mixed with chalk and made up into tablets, or made in paper form. Litmus gives a deep blue color with alkalies and a red with acids, and is used as an indicator of acidity. Azolitmin, $C_7H_7O_4N$, is the coloring matter of litmus, and is a reddish-brown powder.

Locust. The wood of the locust tree, *Robina pseudacacia*, also known as acacia, false acacia, and red locust. The tree is native to North America, but is also grown in Europe and other parts of the world. The tree has beautiful white flowers with a fine odor. The wood is strong and durable, with a weight of 43 to 52 lb. per cu. ft. Its hard-

ness is about the same as ash, and the strength and flexibility is greater than oak. The grain is coarse, but the surface is lustrous and satiny. The ultimate tensile strength reaches 24,800 lb. per sq. in. Locust is used for furniture, automobile wheel spokes, posts, and in construction. The name locust is also applied to the wood of the tree *Hymensea courbaril* of tropical South America. This wood has a brownish color, with an open grain, and it takes a beautiful polish. It is little exported.

Logwood. An extract widely used for black dyeing, or as a darkening constituent in browns, olives, and grays. It is obtained from the large and rapidly growing tree, *Haematoxylon campechianum*, of the West Indies and Central America. The natural wood has a yellowish-brown color which, when exposed, turns a brownish-red. The chipped wood is treated with water and yields 15 per cent of extract. The true coloring matter, hematine, $C_{16}H_{12}O_6$, forms brownish-red crystals, and is only produced in the aged wood, or by oxidation of the white extract of the fresh wood. Logwood, or "hematine," is marketed in crystals, solid extract, water extract, or paste.

Lotens. The trade name of a silicon carbide, made in the electric furnace, and used as an abrasive. It is a product of the Precision Grinding Wheel Company, Inc., Philadelphia. See Silicon carbide.

Lotus metal. The trade name of a lead-base white bearing metal containing fairly high percentages of tin and antimony. It is used for bearings in motors and other high-speed machinery with medium bearing loads. It is a product of the Lumen Bearing Company, Buffalo.

Low brass. One of the standard brass alloys of the brass mills. It contains 80 per cent of copper, and 20 per cent of zinc. It has a yellow color, and is very ductile and easily drawn. It is used for formed and drawn parts that require a high finish.

Lubeco metal. The trade name of a medium-composition babbitt metal used for machine bearings. See Babbitt. It is a product of the Lumen Bearing Company, Buffalo, N. Y.

Lubricating grease. Usually a compound of a soap with a mineral oil, employed for lubricating machinery where the speed is slow, or where it is not possible to hold a free flowing oil. The soap is made with fatty oils or fats containing stearin, olein, or palmatin. Lime is used to form a soap insoluble in water. Mineral lubricating grease usually contains 80 to 90 per cent of mineral oil and the remainder lime soap. Resins or alkalies are not desirable for greases to be used on machinery. Hard grease flows at a temperature of about 90 deg. C., and medium grease flows at 75 to 80 deg. C. Paraffin wax is sometimes added, but is an adulterant and not a lubricant. Graphite grease contains 8 to 10 per cent of amorphous graphite, and is used for bearings, especially in damp places. "Cylinder grease" is made of about 85 per cent of mineral oil and mineral grease, and 15 per cent of tallow. Compounded greases are also marketed containing animal and vegetable oils, or are made by artificially thickening vegetable oils and compounding with mineral oils. The fatty acids in vegetable and animal oils, however, are likely to corrode the machinery.

Lubricating oils. Oils used for lubricating the bearing parts of machinery. They are usually the liquid products obtained in the fractional distillation of petroleum between the temperatures 253 and 317 deg. F. They are the heavier distillates following kerosene, and have the composition $C_{14}H_{13}$ to $C_{18}H_{38}$. They are separated into grades, light, medium, and heavy, depending upon the molecular weight. They are also classed as "pale," when yellow to reddish, or "dark," when brownish-black in color. The specific gravities range above 0.765, more usually from 0.860 to 0.940. The flash point is from 300 to 600 deg. F. For bearing pressures below 400 lb. per sq. in. a refined non-emulsifying mineral oil of viscosity 180 to 200 sec.

Saybolt at 100 deg. F. serves well. For thrust bearings with pressures in excess of 1,000 lb. on presses, a cylinder oil of viscosity of from 130 to 160 sec. Saybolt at 210 deg. F. should be used. Commercial lubricating oils are often bleached with sulphuric acid or other substances, and frequently mixed with vegetable and animal oils, such as rapeseed, cottonseed oil, or fish oils, especially "blown" oils. Good mineral lubricating oils do not deteriorate greatly in use on machines, and can be used over and over by cleaning out the dirt, water, and metal particles by filtering or centrifugal methods. Vegetable and animal oils are apt to become acid in use. Animal oils are more greasy than mineral oils, but are acid. Vegetable oils gum in use. "Jaw oil" from the blackfish is used for fine mechanisms. See also Paraffin oil.

Lucero. The trade name of a non-corrosive alloy used for springs, and electric resistance wire or strip. It contains 70 per cent of nickel and 30 per cent of copper. It will take a brilliant luster finish resembling platinum. It may be operated continuously at temperatures up to 1,100 deg. F. without oxidizing. It has a tensile strength up to 140,000 lb. per sq. in. when cold-worked. The melting point is 1,350 deg. C. The weight is 0.320 lb. per cu. in. Lucero is made by the Driver-Harris Company, Harrison, New Jersey.

Lumdie steel. The trade name of die-casting die steel, used for making dies for aluminum die casting. It is a special composition tungsten-chromium alloy steel, and is a product of the Latrobe Electric Steel Company. It is marketed in billets, bars, and forgings, and is usually furnished annealed.

Lumen alloys. The trade name of a group of bronzes employed for bearings, valves, bells, and other uses. They are made by the Lumen Bearing Company, Buffalo, and marketed under grade numbers. A type used for bells contains 80 per cent copper, 20 per cent tin, and is deoxi-

dized with phosphorous. It has a tensile strength of about 33,000 lb. per sq. in. The same approximate composition with 1 per cent of phosphorous is recommended for high pressure bearings. Another bearing alloy has 84 per cent of copper and 16 of tin. A casting alloy for pumps and machinery parts contain 90 per cent of copper and 10 of tin. It has a tensile strength of 37,000 lb. per sq. in., a reduction in area of about 18 per cent, and is resistant to corrosion. Some alloys also contain zinc or lead or both, while others also contain phosphorus. Some high-lead bronzes for bearings also come in this group.

Lumen bronze. A proprietary white alloy, U. S. patent 778,398, used for machine bearings. It is a product of the Lumen Bearing Company. It consists of 86 per cent of zinc, 9.9 per cent of copper, 4 per cent of aluminum, and 0.1 per cent of magnesium. Modifications of the alloy for casting purposes contains less zinc, and slightly more copper and aluminum, without magnesium. Lumen bronze is essentially the old Fontainemoreau bronze with the addition of aluminum to increase the strength and elasticity. It is claimed to have a tensile strength up to 45,000 lb. per sq. in., a Brinell hardness up to 124, and a compressive strength of 80,000 lb. per sq. in. Another modification such as for pivot bearings, and bearings in machine tools, contains 86 per cent of zinc, 10 of copper, and 4 of aluminum. The tensile strength is 32,000 to 36,000 lb. per sq. in., and it gives a compression of 0.001 in. at 25,000 lb. The Brinell hardness is 114 to 119, and the weight per cu. in. is 0.25 pound.

Lumnite cement. The trade name of a quick-setting portland cement used for roads, settling-bank walls, and other places where it is necessary to develop strength in a short period. It is also valuable in frosty weather. This class of cement was developed during the World War for military construction. Lumnite cement is made with bauxite as the chief raw material. The composition of the cement is approximately 40 per cent alumina, 40 per cent

lime, 15 per cent iron oxides, and 5 per cent of silica, magnesia, and impurities. It dehydrates rapidly, and sets in 24 hours as compared with a 3-week set of ordinary portland cement. A 1-2-4 mixture of this class of cement is claimed to develop about 2,900 lb. per sq. in. compressive strength in one day, and roads made of it can be opened to traffic in 24 hours. Lumnite cement is a product of the Atlas Lumnite Cement Company, New York.

Lusterite. The trade name of a stainless steel produced by the Latrobe Electric Steel Company, Latrobe, Pa. It is a product of the electric furnace, and contains 17 per cent of chromium and 0.90 per cent of carbon. It can be hardened to a high degree, and will hold a cutting edge very well. It is furnished in billets, bars, and cold-drawn rods, usually annealed. It is used for making pocket-knife blades, dental and surgical tools, and all tools where a keen edge is required.

Lutes. Adhesive substances, usually of earthy composition, employed for closing pipe joints or seams to make them tight, or for coating pipes or boilers to protect them from high temperatures. Various clays are used for this purpose, or white lead and oil. Plaster of paris mixed with a weak glue will withstand a dull red heat. "Fat lute" is pipe clay mixed with linseed oil. Linseed meal with lime is also used. Many prepared compounds for this purpose are marketed under trade names. See also Spence's metal.

Lydian stone. Also called touchstone. A species of cherty flint employed for testing gold. It is composed largely of silica, and is of a grayish-black color. The specific gravity is 2.58 to 2.64. It is found widely distributed in massive beds. The gold object to be tested is rubbed on the surface, and the mark is touched with aquafortis. The amount of copper contained in the gold may be estimated by the change in color of the streak.

Lynite. The trade name of a light alloy used for automobile engine pistons. A typical composition is: 90 per

cent of aluminum, 8 of copper, 1.5 of iron, and 0.5 of magnesium. Another grade shows 11.5 to 13.5 per cent of copper, not over 17 per cent of iron and other impurities, and the balance aluminum. This alloy has a specific gravity of 2.97, and a tensile strength of 19,000 lb. per sq. in. It is a product of the Aluminum Company of America, Pittsburgh.

Lyonore metal. A pure grade of open-hearth steel containing about 0.20 per cent of copper, made by the United States Steel Company and marketed by the Lyon Conklin Company, Baltimore, Md. It is claimed to have considerable rust-resistant properties, partly due to its high purity, and partly to the influence of the copper in solution. See also Ingot iron.

Machinery steel. Also called machine steel. A common trade name for open-hearth carbon steels having a usual carbon range from 0.10 to 0.25 per cent. See Ingot iron. They have an elastic limit of from 35,000 to 45,000 lb. per sq. in. Machinery steel will not harden, but can be carburized on the outside by packing in bone black or other carbon material and heating in a furnace. It is then case-hardened by quenching. When properly heat-treated it has a fine grain, giving good wearing qualities on the outside and a tough core. It is used for machinery parts, gears, and cheap dies for cutting paper and thin sheet metal. Machinery steel can be forged readily, and also machines easily. Small amounts of phosphorus are often desired in machinery steel to make it free cutting and to keep the chips from curling. Some special grades of machinery steel contain 0.40 to 0.60 per cent of carbon, having a tensile strength up to 60,000 lb. per sq. in. They are used for shafts, forgings and machine parts where toughness and stiffness are required.

Macht's metal. A trade name for a brass of a golden-yellow color claimed to be suitable for fine castings. It can also be forged at a red heat. It contains 57 per cent

of copper and 43 per cent of zinc. It is now largely replaced by the standard 60-40 brass. "Mach's metal" is a light-weight, white casting alloy containing 2 to 10 per cent of magnesium and the balance aluminum.

Mack's cement. A hard, durable cement consisting of dehydrated gypsum to which a very small percentage of calcined sodium sulphate, Na_2SO_4, or potassium sulphate, K_2SO_4, has been added. The amount of sulphate is usually about 0.4 per cent. The cement sets quickly, and adheres well. It is used chiefly for covering wire mesh on walls and ceilings, and is also used for flooring when mixed with sand or clinker. It is not porous, and will not absorb oil paints well.

Madder. Formerly the most important dyestuff with the exception of indigo. It is now largely replaced by the coal-tar dye alizarin. Madder is the ground root of the plant *Rubia tinctoria*, which has been stored for a time to develop the coloring matter. The color is due to the orange-red alizarin, $C_{14}H_8O_4$, but purpurin, $C_{14}H_8O_5$, is also formed, both of which are now produced synthetically. Madder has been used since prehistoric times in Egypt, and was known to the Greeks previous to 450 B.C. When artificial alizarin was produced from coal tar the madder industry was practically abandoned. Madder yields colors of great permanence.

Madia-seed oil. This drying oil is obtained from the seeds of the plant *Madia sativa*, native to California. It is very similar to the sunflower, and the seeds and oil have similar properties. The seeds contain up to 35 per cent of a yellowish-brown oil of the semi-drying type. The cold pressed oil has a pleasant odor and taste and is edible. The oil is used in paints, or for adulterating other drying oils.

Magnalite. A light aluminum casting alloy used in airplane construction and for automobile pistons. The specific gravity is 2.8, tensile strength 26,000 lb. per sq. in.,

and elongation 2.5 per cent. It consists of 94.2 per cent of aluminum, 2.5 per cent of copper, 1.5 per cent of nickel, 0.5 per cent of zinc, and 1.3 per cent of magnesium. When heat-treated the castings are claimed to have exceptional toughness and strength. The alloy is the product of the Walker M. Levett Company, New York.

Magnalium. A light aluminum casting alloy containing 95 per cent of aluminum and 5 per cent of magnesium. It has a tensile strength of 22,000 lb. per sq. in., and an elongation of 4 per cent. It is used for automobile pistons.

Magnesia cement. Magnesia prepared by heating the chloride or nitrate to redness, 1,200 deg. F., or above. When mixed with water it sets to a rigid mass. Magnesia cement is sometimes used with lime for mortar, and also in fire bricks. See Sorel cement.

Magnesite. A mineral used chiefly in the manufacture of bricks for refractory furnace linings. It is also employed as an ore of magnesium. The ground magnesite is a light powder, and is shaped into bricks at high pressure and baked in kilns. Magnesite is a magnesium carbonate, $MgCO_3$, with iron carbonate often present. It occurs in compact earthy forms, or in granular masses. Its hardness is 3.5 to 4.5, and its specific gravity is 3.1. It has a vitreous luster, and the color is white, gray, yellow or brown. It fuses at 2,165 deg. C. The production of crude magnesite in the United States in 1926 was 133,500 short tons, and the importations were 196,318 tons. California and Italy furnished the largest quantities. Magnesite furnace materials are usually sold under trade names. It is also employed as an insulating covering for steam pipes, and the pure magnesium carbonate is used in boiler compounds.

Magnesium. The lightest metal that is stable under ordinary conditions. It is only two-thirds as heavy as aluminum. The chemical symbol is Mg. It resembles aluminum in color and properties. Its specific gravity is 1.74. It has a tensile strength when cast of 13,000 lb.

per sq. in., an elongation of 2 per cent, and a compressive strength of 32,000 lb. per sq. in. When rolled it has a tensile strength of 25,000 lb. per sq. in., and an elongation of 4 per cent. The Brinell hardness of the cast metal is 30, and of the rolled is 40. The melting point is 651 deg. C., and the boiling point is 1,120 deg. C. Magnesium is too brittle to roll cold, but can be rolled at 300 to 500 deg. C. It is employed for light alloys, especially for airplane and automobile engine use. The rods and shapes are usually extruded. It has also been found to be a good metal for sound-producing resonators. It is immune to attack by alkalis, and is also highly resistant to the action of sea water. It is never used alone, but is alloyed with aluminum. The pure metal ignites easily, and even when alloyed with other metals the fine chips in machining must be guarded against fire. The specific gravity of an alloy with about 10 per cent of aluminum is approximately 1.8. Magnesium is also used as a deoxidizer in casting various metals, and is used for flashlight powders and fireworks. It burns readily, with an intense flame, to magnesia. Magnesium is produced commercially by the electrolysis of a fused chloride or fluoride-oxide. Commercial magnesium is 99.92 per cent pure.

Magnesium alloy. A light-weight metal employed in airplane construction for forged propellers, cast pistons, and extruded structural shapes. The usual composition of the alloy is 96 per cent of magnesium and 4 per cent of aluminum. It has a specific gravity of 1.77, weight of 0.064 lb. per cu. in., a tensile strength cast of 25,000 lb. per sq. in., and an elongation of 9 per cent. It has the disadvantage that it corrodes easily. Other compositions are also used, a common one being 94 per cent of magnesium and 6 per cent of aluminum, and others are 92-8, 90-10, and 88-12 alloys. The tensile strength increases with the addition of aluminum, the 88-12 composition, when heat-treated, giving as high as 50,000 lb. per sq. in., with an elongation of 3 per cent in 2 in., and a Brinell hardness of 82. Magnesium alloys are readily cast, but ignite easily

at temperatures slightly under the melting point. They can also be forged and welded, and they machine more readily than aluminum. Higher speeds can be used than for cutting brass.

Magnesium carbonate. A light, white insoluble powder of the composition $MgCO_3$, containing also crystals with water of crystallization. The specific gravity is 3.10. It is employed as an insulating covering for steam pipes and furnaces, for making oxychloride cement for flooring, and in boiler compounds. See also Magnesite.

Magnetite. An important and common ore of iron. It is found in large beds in northern New York, in various places in New Jersey, and in Pennsylvania. It is the chief ore in Norway and Sweden, and also occurs in Germany and Siberia. Magnetite has the composition $FeO \cdot Fe_2O_3$, containing theoretically 72.4 per cent of iron. It may also contain magnesium, nickel, or titanium. It usually occurs granular massive, or as sand. The specific gravity is 5.18, and the hardness is 6. The color is iron-black, with a metallic luster. It is strongly magnetic, and sometimes occurs as a natural magnet known as lodestone.

Magnet steels. Steels employed for making permanent magnets, that is, magnets that retain their magnetism after they are removed from the magnetic field, as distinct from electro-magnets, which are of soft iron and are only magnetized while in the magnetic field. Magnet steels are usually good grades of crucible tungsten steel, and containing some chromium and manganese. They contain about 0.65 per cent of carbon, and are hardened without drawing the temper. They are "aged" by heating in oil to a temperature of about 250 deg. F., and then placed in a vibrating device. High-cobalt steels have been more recently used for magnet steels, and are claimed to be much superior to tungsten steels for this purpose.

Magno. The trade name of an alloy used for electrical resistance wires. It is made by the Electrical Alloys

Company, and contains 95 per cent of nickel, and 5 per cent of manganese. The coefficient of resistivity is 120 ohms per mil.-ft. at 20 deg. C. The tensile strength when hard drawn is 140,000 lb. per sq. in., and when soft 65,000 lb. per sq. in. Its melting point is 1,420 deg. Centigrade.

Magnolia metal. The trade name of a white "anti-friction" bearing metal produced by the Magnolia Metal Company, and used for machinery bearings. It contains a high percentage of lead, about 80 per cent, with a considerable proportion of antimony. It may also contain some tin. It may also contain small amounts of copper and other elements, especially a little phosphorus or bismuth. It is claimed to have a high compressive strength, and a very low coefficient of friction.

Mahoe. Also called blue mahoe. The wood of the tree *Hibiscus elatus*, of tropical America and the West Indies, employed for making gunstocks as a substitute for walnut. The timber is available in large logs. The wood has a gray-blue color, or sometimes brownish-gray with streaks, and an aromatic odor. It is very hard, with a coarse, open grain.

Mahogany. A name applied to a wide variety of woods. All of the true mahogany, however, comes from trees of the family *Meliaceae*, but of various genera and species. The tropical cedars, "Spanish cedar," and "Paraguayan cedar," belong to this same family. Mahogany, of the tree *Swietenia mahogani*, and other species of *Swietenia*, known locally as caoba, and in the trade as Spanish mahogany, is obtained from Mexico to as far south as northern Argentina. The Central American, chiefly that of Honduras, has the best reputation in commerce. Mahoganies from tropical Africa, chiefly *Khaya senegalensis*, are sold under the names of the shipping ports. The wood of the mahogany trees is obtainable in large logs. It has a reddish color of various shades. The grain is often figured, and it has a high luster when polished. It seasons well, and is much prized for

furniture and cabinet work, and for trim on many kinds of machines. It is much used for small patterns used in foundry work where they must be employed frequently and should not alter in shape. The cheaper grades are used for this purpose. The weight varies from 32 to 42 lb. per cu. ft. The hardness and closeness of the different mahoganies also varies considerably. The beautiful "curled" grain specimens are obtained from forks or crotches in the trees. The annual imports of mahogany into the United States are about 70,000,000 bd. feet.

Malachite. Also known as green copper carbonate. An important ore of copper. It is a basic carbonate of copper, $(Cu{\cdot}OH)_2CO_3$, containing theoretically 57.4 per cent of copper. The structure of the mineral is usually radiating fibrous. It has a hardness of 3.5 to 4, and a specific gravity of 3.0 to 4.1. The color is bright green. In crystal form it has a vitreous luster, but in the earthy form it is dull.

Malleable iron. A high-tensile-strength white cast iron made by oxidizing the carbon in white chilled castings. Iron for malleable iron is usually melted in the reverberatory furnace, which gives it greater strength and ductility than iron melted in the cupola in contact with the fuel. Malleable iron is used for castings for implements, pipe fittings, and small machine parts requiring strength. The tensile strength is above 50,000 lb. sq. in., and elongation 10 per cent in 2 in. The castings seldom exceed 10 lb. in weight. After casting, the parts are packed in annealing pots with hammer scale or oxidized turnings or borings, and subjected to a red heat, about 1,650 deg. F., for over 60 hours. They are then cooled slowly for about 40 hours. The resulting iron has the carbon in regular tiny particles instead of flakes as in gray cast iron. Malleable iron is costly due to the great length of time required for heating and cooling, and is, therefore, often replaced by semi-steel castings, heat-treated chilled gray iron castings, manganese brass, or steel.

Manganese. A metallic element, symbol Mn. It is found in the minerals manganite, pyrolusite, and others, with most iron ores, and traces in most rocks. A manganese ore of commercial value usually contains at least 40 per cent of metallic manganese, but ores of a lower content can be smelted in the electric furnace. Manganese has a silvery-white color with purplish shades. It is very brittle. The specific gravity is 7.42, melting point 2,237 deg. F., and weight 0.268 lb. per cu. in. It is used in the steel industry as a deoxidizer and as a hardener, and nearly all steel now contains some manganese. For this purpose it is used largely in the form of ferro-manganese. The American consumption of manganese ore is 800,000 tons annually, of which 750,000 tons are used for deoxidizing and alloying with steel and bronze, and 50,000 tons are used in dry-cell batteries, bricks, glass, chemicals and paints. Most of the ore comes from Russia, Brazil and India. The American ores from the Southeast and Northwest are generally low grade, but can be used when the need is great. Commercial manganese metal, for adding manganese to non-ferrous alloys, is marketed in crushed form containing 95 to 97 per cent of manganese, a maximum of 2 to 3 per cent of iron, a maximum of 1 per cent of silicon and 0.25 maximum of carbon. A manganese-boron, containing 20 to 25 per cent of boron, is employed in Europe for deoxidizing and hardening bronzes.

Manganese bronze. This alloy is an iron- and manganese-bearing brass. It is used for propeller blades, valve stems, engine frames, and machinery parts requiring strength and toughness. It is sometimes used to replace steel castings where rust-resistance is important. The zinc content is varied as in brasses, additional zinc giving hardness and strength with less ductility. Iron is usually an impurity, but adds strength to the alloy. Aluminum is added to balance the effect of the iron. Manganese is chiefly a deoxidizer, but is usually present in excess. A typical manganese bronze contains 57 per cent of copper, 40.5 per cent of

zinc, 0.75 of tin, 1 of iron, 0.5 of aluminum, and 0.25 of manganese. This mix is alloy No. 9 of William H. Barr, Inc., Buffalo. It has a tensile strength of 65,000 to 85,000 lb. per sq. in., elongation 18 to 35 per cent in 2 in., Brinell hardness 105 to 119, and specific gravity of 8.4. See also Bronze.

Manganese casting brass. The commercial name of a brass containing a small amount of manganese. It has a high tensile strength, and is capable of making clean, dense castings. The composition employed by the General Motors Corporation is 58 per cent of copper, 40 of zinc, and 2 of an alloy consisting of tin, iron, manganese, and aluminum. The lead content of the brass is not permitted to exceed 0.15 per cent. The tensile strength is 70,000 lb. per sq. in., and the elongation in 2 in. is 20 per cent. Manganese brass is used generally as a substitute for malleable iron or drop-forged steel.

Manganese copper. An alloy of the metals manganese and copper, containing usually 25 or 30 per cent of manganese. It is used as a deoxidizer in making certain non-ferrous alloys, especially brass, cupro-nickel, and German silver, and also for adding manganese to manganese bronze. The best grades of manganese copper are made from metallic manganese, and are free from iron. Grades made from ferro-manganese contain some iron. Manganese copper is usually marketed in slabs with notched sections for breaking into pieces, or as shot. It has a lower melting point than metallic manganese, and is thus more easily dissolved in the brass or bronze.

Manganese green. The common name for barium manganate, $BaMnO_4$, which is a green powder used as a paint pigment. It is also known as Cassel's green. It is poisonous, insoluble in water, and has a specific gravity of 4.85. It is made by heating together manganese dioxide, barium nitrate, and barium sulphate.

Manganese steel. All commercial steels contain some manganese which has been introduced in the process of

deoxidizing with ferro-manganese, but the name usually is applied only to steels containing from 10 to 15 per cent of manganese, although other "low-manganese" steels are on the market. The original Hadfield manganese steel made in 1883 contained 10 to 14.5 per cent of manganese and 1 per cent of carbon. Manganese increases the hardness and tensile strength of steel. In the absence of carbon, manganese up to 1.5 per cent has only slight influence on iron, but as the carbon content increases the effect intensifies. Structural steels with 0.50 per cent of carbon and from 1 to 2 per cent of manganese have a tensile strength of about 175,000 lb. per sq. in., and an elongation of 10 to 20 per cent in 2 in. Low-manganese plates for shipbuilding contain about 1.25 per cent of manganese, 0.30 of carbon, and have a tensile strength of about 90,000 lb. per sq. in. A 2 per cent manganese steel is claimed to be easily forged, and as readily heat-treated as a 3½-per cent nickel steel. Manganese screw stock contains 1 per cent of manganese and 0.10 per cent of sulphur. It is tough, and easily machined. Medium-manganese steels are very brittle, and percentages from 2 to 9 are not ordinarily used. The bulk of high-manganese steels contain from 11 to 14 per cent of manganese with about 1.20 per cent of carbon. These steels are used in castings and forgings for machine parts subject to great wear and abrasion, such as the teeth of steam shovels, crusher parts, rolling-mill gears, and tractor treads. They are not commercially machinable with ordinary tools, but can be cut and drilled with tungsten carbide and diamond tools. Manganese steel castings are heat-treated by quenching from a temperature of about 1,800 deg. F., and then drawing at a temperature of 400 to 700 deg. F. The Brinell hardness is from 170 to 200. Manganese steels are non-magnetic. The coefficient of expansion is about twice that of ordinary steel, and this must be allowed for in making the pattern.

Manganin. A non-ferrous alloy made by the Driver-Harris Company, and used for coils and shunt wires in

electrical instruments. It is also furnished in sheet and used for springs in instruments and automobile horns. It contains from 70 to 85 per cent of copper, from 2 to 5 per cent of nickel, from 12 to 25 per cent of manganese, and a trace of iron. Its tensile strength is 70,000 lb. per sq. in. Manganin is very malleable and ductile. The specific resistance is 270 ohms per circular mil.-ft. Its coefficient of expansion is very low. The weight is 0.294 lb. per cu. inch.

Manganite. A minor ore of the metal manganese, found with other manganese minerals and with iron oxides. It occurs in Germany, England, and in the Lake Superior region of the United States. The composition is $Mn_2O_3 \cdot H_2O$, containing theoretically 62.4 per cent of manganese. It usually occurs in radiating masses, having a specific gravity of 4.3, and a hardness of 4. The color is steel-gray to iron-black.

Mangrove. An extract obtained from the bark of the red mangrove tree, *Rhizophora mangla*, the white mangrove, *Laguncularia racemosa*, and other species of Africa, the East Indies, and southern Asia. The bark usually contains about 35 per cent of tannin. It is used in tanning and in dyeing. Red mangrove bark contains a red coloring matter, which is objectionable in tanning. White mangrove contains a yellow coloring matter. The solid extract sold in blocks contains as high as 68 per cent of tannin, although East African varieties contain as low as 24 per cent. The liquid extract contains about 25 per cent. The extract is decolorized by blood albumin unless it is to be used as a dye. White mangrove produces a light-colored leather.

Manila hemp. A fiber obtained from the leaf-stalks of the abaca plant, *Musa textilis*, a tree of the banana family growing in the Philippines. It is employed for rope and cordage, and is the strongest of the vegetable fibers. The fibers are also very long, from 4 to 8 ft., and they do not stiffen when wet. They are light in weight, soft and lustrous. It is put up for shipment in bales of 270 pounds.

The finest fibers, called "lupis," are used locally for weaving into cloth. The plant grows to a height of 20 to 30 ft., with the hugh leaves characteristic of the banana. It develops flowers in three years, and is then cut down for the fiber.

Manketti oil. A drying oil used in varnishes, and obtained from the seed nuts of the tree *Ricinodendron rautanenii*, native to southwest Africa. The seeds weigh about 1.5 grams each, and contain 60 per cent kernel which yield up to 60 per cent of oil. Manketti oil is light-yellow in color, viscous, and has a pleasant odor and taste. It has about two-thirds of the drying power of linseed oil. The nuts of the tree *R. africanum*, of the French Congo, yield a similar oil, which is superior as a drying oil.

Mannheim gold. A trade name for a brass with a fine golden-yellow color, used for making cheap jewelry, or for other articles in imitation of gold. Its composition varies, but it contains about 83 per cent of copper, up to 10 per cent of zinc, and up to 7 per cent of tin. See Gilding metal.

Maple. The wood of several varieties of maple trees native to the United States and Canada. These include the sugar maple, *Acer saccharum*, the broad-leaved maple, *Acer macrophyllum*, and the vine maple, *A. circinnatum*. The wood may be white or yellowish to brownish, and is close-grained and hard. It often has a curly, twisted grain. The weight is about 41 lb. per cu. ft. Maple is used for furniture, cabinet work, flooring, veneers, and for such machine parts as rollers, where a hard, fine-grained wood is needed. It is also used for the turned parts of foundry patterns. The production in the United States in 1925 was 921,566,000 bd. feet.

Marble. A crystalline limestone used widely for ornamental building, for large slabs for electric power panels, and for ornaments and statuary. In the broad sense, marble includes any limestone that can be polished,

including breccia, onyx, and others. Pure limestone would naturally be white, but marble is usually streaked and variegated in many colors. The marble of Carrara, Italy, is the most famous, being of delicate texture and very white. It is also hard and brittle. In the United States the marbles of Vermont are the most noted, and occur in many varieties. For great variety of beautiful colors the marbles of southern Uruguay are famous, and they occur in immense blocks. The weight of marble is about 170 lb. per cu. ft., the specific gravity is 2.72, and the crushing strength is 10,000 lb. per sq. inch.

Marblewood. A variety of ebony which comes from the tree *Diospyros kurzii*, of India. It is also called Andaman marblewood, when it comes from the Andaman Islands. The wood is black with yellowish stripes. It has a close, hard, firm texture, and will take a fine polish. The weight is about 66 lb. per cu. ft. It is employed where a very hard, close-grained wood is required.

Martonite. The name of a French lachramatory poison used in chemical warfare. It is made by adding bromine and sulphuric acid to acetone, and is a mixture of 4 molecules of bromoacetone with 1 molecule of chloroacetone, or about 80 per cent of the former and about 20 per cent of the latter. Martonite is a colorless liquid, which is thrown in high-explosive shells, and disseminated as a mist. See also Poison gases, and Bromoacetone.

Masonite. An insulating wood-fiber board produced by the Mason Fibre Company, Laurel, Miss. It is made from by-product wood chips reduced to the cellulose fibers by high-pressure steam. The long fiber and the lignin cement of the wood are claimed to be retained, and no chemicals are used in pressing the pulp into boards.

Mastic. The gum-resin exudation of the *Pistacia lentiscus*, a small tree native to the Mediterranean countries. It is used for lacquers and varnishes, and also for adhesives. The gum is obtained by making an incision in the tree, each

tree yielding 6 to 11 lb. annually. The annual production is more than a million pounds. The gum hardens and forms the mastic resin of commerce. It is easily soluble in turpentine. When distilled, the resin yields 2 to 3 per cent of a yellowish essential oil, of specific gravity 0.858, resembling oil of rue and savin in odor. Mastic takes its name from the fact that it is used in chewing gums.

Mauritius hemp. The fiber obtained from the fleshy leaves of the plant *Furcraea gigantea*, of Mauritius. It is employed for cordage and rope. The plant belongs to the lily family, and other very similar fibers are obtained from other species, notably *Furcraea foetida*, of Brazil, and *Furcraea cabuya*, of Central America. See Hemp.

Maxel steel. The trade name of a chrome-manganese steel made by the Crucible Steel Company of America, and employed for machinery forgings requiring great strength. It is made in two grades, one with low carbon content for case-hardening purposes, and the other with higher carbon for general forging. The latter steel in its natural condition has a tensile strength of 110,000 lb. per sq. in., and an elongation of 16 per cent in 2 in. By quenching in oil at 1,450 deg. F., and drawing to 850 deg. F., the tensile strength is increased to 205,000 lb. per sq. inch.

Maxite. The trade name of a super high-speed steel made by the Columbia Tool Steel Company, Chicago Heights, Ill. It is marketed in the annealed state, and can be machined. It is hardened by preheating at 1,550 to 1,660 deg. F., then raising to 2,500 deg. F., and quenching in oil. It is then drawn at a temperature of 1,050 to 1,100 deg. F. See High-speed steel.

Mayari iron. The name given to iron made from Cuban ores. These ores naturally contain small percentages of vanadium and titanium, and castings made from the iron have great strength and resistance to wear. They are considered especially suitable for sugar-mill rolls.

McGill metal. The trade name of an "aluminum bronze," employed chiefly as a casting metal for gears, bushings, bearings, ball-bearing retainers, and for machine parts where corrosion- and acid-resistance are valuable. A typical analysis is: 89 per cent of copper, 9 of aluminum, and 2 of iron. It has a tensile strength of 70,000 to 80,000 lb. per sq. in., an elongation of 10 to 20 per cent in 2 in., Brinell hardness of 160, and a compression of 0.001 in. under 35,000 lb. per sq. in. pressure. The weight is 0.270 lb. per cu. in. It has 12.15 per cent of the electric conductivity of copper. The metal has a melting point of 1,870 deg. F. It machines about the same as medium carbon steel, and can be forged or rolled much like carbon steels. It is made by the McGill Metal Company, Valparaiso, Ind.

Meerschaum. A soft, white or gray mineral of the composition $3SiO_2 \cdot 2MgO \cdot 2H_2O$, used chiefly for making tobacco pipes and cigar holders, but also employed for various articles, as it can be cut easily and will withstand heat. The hardness is about 2, and the specific gravity is 1.28. When fresh the mineral absorbs grease and makes a lather. Its German name means sea foam. Most of the commercial meerschaum comes from Asia Minor. It also occurs in Greece, Morroco, and Spain, but the center of the trade is Vienna. Much imitation meerschaum is made from meerschaum shavings, kieselguhr, and from silicates of aluminum, calcium, and magnesium.

Menhaden oil. A fish oil used as a substitute or adulterant of linseed oil, and also for mixing with mineral oils for use as cutting oils, and also for dressing leather. It is obtained by steaming the body of the fish *Alosa menhaden*, which is found along the Atlantic Coast of America. The fish yields up to 15 per cent of oil, and the residue is used as fertilizer. The better qualities of the oil are bleached with fullers' earth. Inferior oils are obtained by pressure from the residue, or from putrid fish. Menhaden oil contains about 23 per cent of palmitic acid. The specific gravity is 0.927 to 0.933. Its iodine value is high, up to 180, and it

therefore has good drying properties, but it does not form an elastic skin on drying as do the vegetable oils. Its strong odor is largely due to clupanodonic acid, $C_{17}H_{27}COOH$, which it contains.

Mercerized cotton. Cotton yarns treated with sodium hydroxide. The treatment gives a fine, silky luster to the yarn, makes it stronger, and practically non-shrinking. It was discovered accidentally in 1851 by John Mercer of Lancashire. The present process consists in immersing the yarns in a stretched condition in the soda, and after washing, neutralizing the remaining alkali with dilute sulphuric acid. The stretching of the yarns prevents excessive shrinking. Mercerized cotton has a greater affinity for dyes than untreated cotton. Mercerized yarns have a great variety of uses, and when mixed with silk cannot be detected easily by ordinary observation.

Merchant bar iron. Wrought iron in the form of merchantable bars or rods made by shearing the first muck bars from the bloom into short lengths of 2 to 3 ft., tying 5 or 7 together, "faggoting," and hot rolling or forging. Merchant bar iron is produced in flats, squares, or rounds. Double-refined iron is merchant bar that has been recut, faggoted, and rerolled.

Mercury. Also called quicksilver. A metallic element, symbol Hg. It is the only metal that is liquid at ordinary temperatures. Mercury has a silvery-white color and a high luster. Its specific gravity is 13.596. The solidifying point is −40 deg. F., and its boiling point is 662 deg. F. It does not oxidize at ordinary temperatures, but when heated to near its boiling point it absorbs oxygen and is converted into a red crystalline powder, mercuric oxide. Mercury is derived chiefly from the mineral cinnabar. The metal is marketed in iron flasks holding 75 lb. European flasks hold 76 lb. Mercury is used for separating gold and silver from their ores, for coating mirrors, as an expansive material in thermometers, and in amalgams with

other metals. The nitrogen compound is used as a detonator for explosives. The world production of mercury reaches 4,000 tons of the metal annually.

Mercury fulminate. A gray or brown sandy powder of the composition $Hg(CNO)_2$, which is the basis of most detonating compositions used for high explosives. Mercury fulminate is made by the action of nitric acid on mercury and alcohol, and is ten times as sensitive as an explosive as picric acid. It is frequently mixed with potassium chlorite and antimony sulphide for percussion caps. The requisites of a detonator are that it be ignited easily, and reach a maximum rate of detonation quickly. Mercury fulminate is claimed to fulfill these requirements. See also Lead azide.

Merkus pine. The wood of the tropical pine tree, *Pinus merkusii*, of the East Indies, and cultivated on plantations in North Sumatra. It is a valuable construction timber, but it is most prized because of the superior quality of the turpentine which it yields. It is claimed that the merkus pine will eventually become the chief source of turpentine. See Turpentine.

Mesothorium. A radioactive body occurring in the rare earth minerals. It is separated out of monazite sand and other thorium ores as a by-product of the thorium industry in the manufacture of incandescent gas mantels. Mesothorium is identical in chemical properties with radium, and cannot be separated from radium if mixed with it. A disadvantage of mesothorium, however, is that it decays, decreasing to half value in 5.5 years. The radiations from mesothorium are the same as from radium, α, β, and γ rays being sent off. As it decomposes it forms radiothorium, which is identical in chemical properties to thorium, but gives off a powerful α radiation. Mesothorium is used as a substitute for radium in luminous paints.

Methane. Also known commonly as marsh gas, and in mines as "fire damp." A colorless, odorless gas of the composition CH_4, employed for carbonizing steels. Meth-

ane occurs naturally from the decomposition of plant and animal life, and is produced artificially by the direct union of carbon or carbon monoxide and hydrogen. The specific gravity is about 0.560. It is much lighter than air, and is easily diffused in air. A mixture of one part in 18 parts of air is highly explosive. The gas alone is not explosive, but is broken up by the hot steel in the furnace, and the released carbon enters and carbonizes the steel.

Methyl alcohol. Also called methanol, and commonly known as wood alcohol. A colorless liquid of the composition CH_3OH, obtained from the distillation of hard woods. It is used as a solvent in lacquers, varnishes, and shellac. It is also used for denaturing ethyl alcohol. On oxidation it yields formaldehyde, and its widest use is in making the latter product for synthetic molding materials. The specific gravity of methyl alcohol is 0.791, the solidifying point is -98 deg. C., and the boiling point is 66 deg. C. It is a poison. In small doses it causes blindness, but in larger doses causes death. The production in the United States is more than 600,000 gallons monthly. "Methylated spirits" is ethyl alcohol made unfit for beverage purposes by the addition of about 10 per cent of methyl alcohol.

Methyl chloride. A compound with the composition CH_3Cl, which at ordinary temperatures is a gas, but can be liquified by compression. It is employed in small refrigerator plants in place of ammonia.

Met-L-Wood. A trade name for a panelling board made up of two layers of light wood separated by sheet steel. It has also a fabric cemented to one side, the whole being cemented and pressed into one firm board. The board has great strength in proportion to its weight, and the fabric makes it additionally strong by distributing the load over the entire surface of the panel. It is used chiefly for automobile and truck sides, and is a product of the Met-L-Wood Corporation, Chicago, Ill.

Mica. A group of minerals with monoclinic crystals which break off easily into thin, tough scales, varying in color from colorless to black. Moscovite is the common variety of mica, and is called potash silicate, $H_2KAl_3(SiO_4)_3$, or potash mica. The magnesium mica known as phlogopite of the composition $H_2KMgSi\ (Si\ O_4)_3$, is distinguished from moscovite by its decomposition in sulphuric acid. The colorless moscovite is used for doors in stoves, and known as isinglass. It is also valued as an insulating material against heat and electricity. The brown micas containing iron are valueless as electric insulating material. The specific gravity of mica is from 2.7 to 3.1, and its hardness is from 2 to 3 on the Moh scale. About 70 per cent of the world's supply of mica comes from India. Argentina is also a large producer. It is graded according to size of sheet. In India "books" of mica have been obtained as large as 15 ft., and sheets as large as 24 by 30 in. without flaws. The small pieces are used in lubricants, and are also ground and used as filler in synthetic molding compounds such as Mycalex.

Micarta. The trade name of a molding material composed of paper impregnated with Bakelite, and compressed under hydraulic pressure. It is used chiefly for gears and electrical parts. It is a dark-colored, hard, homogeneous material, with a specific gravity of 1.25, and a tensile strength of 20,000 lb. per sq. in. It is a good electric insulator. It is not fusible, and will withstand temperatures up to 260 deg. C. without decomposition. It can be machined with sharp tools. Micarta is a product of the Westinghouse Electric and Manufacturing Company.

Millerite. A minor ore of the metal nickel, occurring in Europe and in various parts of the United States. It is a nickel sulphide, NiS, containing theoretically 64.7 per cent of nickel. It is usually found in radiating groups of slender crystals, having a specific gravity of 5.65, and a hardness of 3.5. It has a pale-yellow color, and a metallic luster.

Mimetite. A minor ore of the metal lead. It is a secondary mineral occurring in the upper portions of lead veins. It is found in England, Saxony, Siberia, and a few places in the United States. Mimetite has the composition $Pb_4(PbCl)(AsO_4)_3$, with sometimes calcium and phosphorus. The specific gravity is about 7.2, and hardness 3.5. It occurs in rounded crystals of a resinous luster, from colorless to brown.

Minargent. An alloy used as a substitute for silver in making silverware. It has a beautiful silvery color. Its composition is given as 100 parts of copper, 70 of nickel, 5 of tungsten, and 1 of aluminum.

Minelite. The trade name of a blasting powder which is a form of cheddite. It contains heavy petroleum oils and paraffin wax as the carrying mediums for the chlorate. See Cheddite.

Mineral wool. A fibrous material employed for a heat insulator in walls, and also for "deadening," and as a sound insulator or muffler in walls. It is made by mixing stone with the molten slag from blast furnaces and blowing steam through it. Mineral wool usually consists of a mass of fine, pliant, vitreous fibers. The color may be white, yellow, gray, or blackish. It is incombustible, and a nonconductor of heat. "Rock wool" is made in the same way from granite rock, and is claimed to be superior and more regular than the common mineral wool.

Mira metal. The trade name of an acid- and corrosion-resisting casting alloy used for valves and pipes. A typical analysis shows a content of about 75 per cent copper, 16.3 per cent lead, 6.8 antimony, 0.24 of nickel, 0.43 iron, 0.62 zinc, and 0.91 per cent of tin.

Misch metal. A natural mixture of the metals cerium, lanthanum and didymium, used as a pyrophoric alloy in cigarette lighters. The waste matter from monazite sand after the extraction of the thorium oxide used in the incan-

descent mantle industry contains large quantities of cerium oxide, and the rare earth metals lanthanum and didymium, ittyria, and other substances. This is reduced to the metallic state by converting the oxides to chlorides and then removing the metal by electrolysis. The material obtained is an alloy containing 50 per cent cerium, and 45 per cent lanthanum and didymium. It is called Misch metal, the German name for mixed metal. It is employed in making the pyrophoric alloy known as Auer metal. Another important use is as a "getter" for removing gases from radio tubes.

Misco. The trade name of a heat-resistant alloy marketed by the Michigan Steel Casting Company, Detroit. See Heat-resistant alloys.

Mixed acid. A name used in the nitro-cellulose and dyestuffs industries for any mixture of nitric and sulphuric acids. Standard mixed acid contains 36 per cent of nitric, and 61 per cent of sulphuric. Mixed acid is used chiefly in the preparation of pyroxylin and nitro-cellulose.

M-M-M alloy. A copper-tin-nickel alloy known as modified monel metal, manufactured by Manning, Maxwell & Moore, Inc., New York. It is used for valves for superheated steam. It is easily cast into difficult shapes and into thin sections. Its composition is: Nickel 60 to 65 per cent; copper 24 to 27 per cent; tin, 9 to 11 per cent; and small proportions of iron, silicon, and manganese. It has a tensile strength of 70,000 lb. per sq. in., and a compressive strength of 40,000 lb. per sq. in., with elongation of 5 per cent in 2 inches.

Modified gun metal. A bronze containing lead and zinc. It is used for cast bearings and gears not subject to severe service. A typical modified gun metal made by William H. Barr, Inc., Buffalo, known as "Alloy No. 2" contains 86 per cent copper, 9.5 tin, 2.5 lead, and 2 zinc. It has a tensile strength of 32,000 to 40,000 lb. per sq. in., elongation 15 to 25 per cent in 2 in., reduction of area 12 to 23 per cent,

Brinell hardness 63 to 72, specific gravity 8.6, and weight per cu. in. of 0.31 pound.

Molding sand. Any sand employed for making molds for casting purposes. The sands used must be refractory, and must contain enough alumina to make them bind. They may contain from 80 to 92 per cent of silica, up to about 15 per cent of alumina, about 2 per cent of iron oxide, and not more than a trace of lime. Some molding sand contains enough clay or loam to bond it when tamped into place. Sands without natural bond are more refractory and are used for steel molding. Sand for steel casting must contain over 90 per cent of silica, preferably 98 per cent, and are mixed with about 6 to 10 per cent of fireclay. These are usually called silica sand, as distinct from foundry or molding sand. Molding sands may contain from 5 to 18 per cent of clay substances. About 25 per cent of a medium molding sand will be retained on a 150 mesh sieve, and about 10 per cent on a 200 mesh sieve. Sand with rounded grains is preferred. The commercial production of molding sand in the United States in 1924 was 4,404,000 short tons.

Molybdenite. An ore of the metal molybdenum. It is a molybdenum disulphide, MoS_2, containing 60 per cent of molybdenum. The mineral occurs in granite, gneiss, and granular limestone. It is found at various points in the United States. Molybdenite resembles graphite in appearance. Its color is lead-gray, its luster is metallic, and it has a greasy feel. The hardness is 1, and the specific gravity is 4.75. It is infusible. The American production of molybdenite is entirely from Colorado and New Mexico. The ore and concentrates produced in 1925 amounted to 1,154,000 pounds.

Molybdenum. A silvery-white metal, symbol Mo. It occurs chiefly in the mineral molybdenite. The metal has a specific gravity of 10.2, and a melting point of 4,625 deg. F. It is ductile and can be forged. The tensile strength when rolled is 260,000 lb. per sq. in. It has the property like

tungsten of giving steel the quality of red hardness, and it is used in "high-speed steels." Molybdenum, when alloyed with steel in small quantities, also increases the elastic limit of the steel, and makes it wear-resistant. It is used in special steel alloys, and also as a deoxidizer of steel. The amount of molybdenum employed in molybdenum structural steel is from 0.25 to 0.75 per cent. Molybdenum is introduced into steel in the form of ferro-molybdenum, or calcium molybdate. Molybdenum reduces grain size in the steel, and strengthens the crystalline structure. It forms carbides, and also goes into solid solution. It also permits a wider range of heat-treating. A 0.20-per cent addition of molybdenum increases the strength of steel as much as 25 per cent. Molybdenum steels are used for ball bearings and for automotive parts, armor plate, construction tools such as shovels, and in high-carbon tool steel for chisels and cutting tools. The ancient Damascus and Toledo blades were of molybdenum steel, the molybdenum being included unknowingly as an impurity in the iron. Molybdenum metal is marketed in the form of sheets and wire, and is used for voltage rectifiers and for plates in oscillators. See also Chrome-molybdenum steel.

Monazite. A mineral, usually occurring as sand or in granular masses, and useful as the chief source of thorium oxide for gas mantles, and of the "Misch metal" for pyrophoric alloys. Most of the world's supply comes from sea sand found on the coast of Brazil. It is a phosphate of the cerium metals $(CeLaY)PO_4$, with thorium silicate, $ThSiO_4$. Its specific gravity is 5.2, and hardness is 5.5. It has a resinous luster, and a yellowish to reddish-brown color. See also Misch metal, and Thorium.

Mond metal. A trade name for a nickel-copper alloy containing manganese. The approximate composition is 70 per cent of nickel, 26 per cent of copper, and 4 per cent of manganese. It is a product of the American Nickel Corporation. Mond metal is claimed to combine a high tensile strength with malleability, ductility, and resistance to

shock. It also possesses the corrosion- and acid-resisting properties characteristic of nickel-copper alloys. It can be forged, hot-rolled, and welded, and can be machined readily. Mond metal is employed for parts for chemical and mining machinery, and in other places where corrosion-resistance is valued.

Monel metal. This natural alloy was introduced in 1905 by the International Nickel Company. It is produced directly from Canadian Bessemer matte by reducing the ore. The average composition is: Nickel 67 per cent, copper 28 per cent, iron, manganese, silicon, and other elements 5 per cent. The alloy may be cast, rolled, or forged, and can be annealed after cold-working. It can be welded with a gas torch without a flux. Its melting point is about 2,450 deg. F. Monel metal is resistant to corrosion, and also resists the action of many acids. It will retain its bright nickel finish under ordinary conditions. It is employed for making screens, parts for chemical and mining machinery, fittings exposed to corrosive conditions, and such articles as golf-stick heads. See also M-M-M alloy.

Monox. The trade name of a brown powder used as a pigment. For oil painting it is valued because it takes up a higher proportion of oils than ochres or red lead. Monox is an anhydrous protoxide of silicon, of the composition SiO, made by reducing silica and carbon in the electric furnace and condensing the resulting vapor out of contact with the air. The specific gravity is 2.24. It is less soluble in hydrochloric acid than silica.

Mordant. A substance used in dyeing for fixing the color. A mordant must have an affinity for the material being dyed, and at the same time the property of combining with the dyestuff. The vegetable fibers, such as cotton and linen, frequently require mordants. The mordant may be applied first, usually in a hot solution, or simultaneously with the dye. Besides fixing the color, mordants sometimes also increase the brilliancy of the dye. In gilding, a viscous

or sticky substance employed to make the gold leaf adhere may be called a mordant, although it does not have the same "biting" action. A common mordant is alum. Chromium, aluminum, and other salts are also used. Mordants may change the color of the dye. Morin, for example, with an aluminum salt produces a yellow color, but with chromium it produces olive-brown.

Morin. A dyestuff occurring in pale-yellow needles soluble in alkaline solutions. It is produced as an extract from the wood of the tree *Chlorophora tinctoria*, known in the trade as fustic or Cuba wood. The liquid extract on standing separates into two layers, the lower consisting of morin, $C_{15}H_{10}O_6$, and the upper of maclurin, $C_{13}H_{10}O_6$. Fustic extracts are mordant dyes, and produce colors from yellow to olive with various mordants.

Moscovite. A name for the common variety of mica, which is used very largely as an electrical insulator. See Mica.

Mother of pearl. The hard, brilliant-colored internal layer of the pearl oyster shell, and of certain other marine shell fish. It is employed for knife handles, buttons, and other articles. Large oysters of the Indian Ocean, especially off Ceylon, and in the Persian Gulf, furnish the best mother of pearl. The iridescent appearance is due to the structure of the nacre coating. Mother of pearl is very brittle, but can be worked with steel saws and drills using a weak acid lubricant.

Mucilage. A sticky substance obtained from linseed and other seeds, and employed as an adhesive. The seeds are infused in hot water, bruised, and strained. The gummy substance, which contains arabinose, glucose, and galactose, is precipitated, and a heavy solution is known as mucilage. It is easily soluble in water, and can therefore only find use as a light cementing material for paper.

Mullite. A compound of 3 molecules of alumina, Al_2O_3, with 2 molecules of silica, SiO_2, employed as a refractory

material for firebrick and furnace linings. The fusion point of mullite is 3,290 deg. F. It is made by a prolonged fusing in the electric furnace of a mixture of silica sand and bauxite. If an excess of alumina is present it forms as glass.

Muntz metal. The name applied to a group of brasses containing approximately 60 per cent of copper and 40 of zinc. It is also called malleable brass. It is used for ship sheathing, and for large sheets. It is also employed for bolts and rivets exposed to the action of sea water. It can be hot-rolled as well as cold-rolled. Muntz metal was patented in 1832 by an Englishman named Muntz, from whom it took its name. See Brass.

Muriatic acid. A name used in the trade for hydrochloric acid, used extensively as a pickling acid. See Hydrochloric acid.

Mushet steel. The trade name of a group of high-speed steels made by Samuel Osborn & Company, Ltd., Sheffield, England. Mushet steels were the first of the air-hardening, or high-speed steels, but the present grades are different in composition from the original, which contained only 8 to 9 per cent of tungsten. Early Mushet steel also contained small amounts of silver. Mushet high-speed steels are now marketed as "Mushet," "Double Mushet," and "Triple Mushet." They are forged at a yellow heat. For hardening, the steels are heated to a temperature of 1,250 to 1,300 deg. C., and cooled in an air blast or oil bath. See High-speed steel.

Music wire. A high-grade, uniform variety of steel originally intended for strings for musical instruments, but now employed widely for the manufacture of spiral springs. The tensile strength, when hard-drawn, is from 275,000 to 350,000 lb. per sq. in., but it should be tough enough to bend 180 deg. flat upon itself without cracking. The wire is usually marketed in gage sizes according to the Washburn & Moen and the music-wire gage. Wire below 0.034 in. in

diameter (No. 15 gage) is furnished on reels. Larger sizes are in coils. See also Piano wire.

Muslin. A general name for a plain white cotton fabric with a downy nap on the surface. It has a great variety of uses, and industrially is employed for filtering, sacking, and lining. The full-bleached muslin is usually made of finer yarns than the unbleached. In the cheaper grades it is sometimes heavily sized, which disappears on washing. For polishing cloths it should be without filling or sizing.

Mustard gas. A substance of the composition $(CH_2Cl\text{-}CH_2)_2S$, known chemically as di-chloro-ethyl sulphide, and used as a poison gas in chemical warfare. It is made by the action of sulphur monochloride on ethylene. It is an oily liquid which boils at 216 deg. C., and vaporizes easily in the air. It is employed as a lethal gas, and is very painful and poisonous when inhaled. It has the smell of water cress, but when impure has a faint odor of mustard. The specific gravity at 20 deg. C. is 1.2741. Mustard gas irritates the eyes and destroys the cornea superficially. It blisters the skin, affects the lungs, and causes discharge from the nose and vomiting. One part in 14 million parts of air is toxic, and is dangerous in dilutions that cannot be detected by the smell. In warfare, "detectors" of analine dyes or chrome yellow are used, which change color on the presence of mustard gas in the air. Mustard gas was known as "Yellow Cross" during the World war. It is also called Yperite. See also Poison gases.

Mycalex. The trade name of an insulating material used for molding into radio and electrical parts. It is composed of ground mica and lead borate, heated together to the softening point of the borate, 675 deg. C., and compressed while plastic. The fused borate combines with enough of the mica to form a lead boro-silicate, thus providing a greater degree of insolubility, and a higher softening point than in the original material. Mycalex is claimed to be highly heat-resistant as compared with organic resins,

and has high mechanical strength. It is a product of the General Electric Company.

Naphtha. Also known as petroleum ether, and sometimes synonymous with benzine. It is the first liquid to distill off in the fractional distillation of petroleum oils. It is a hydrocarbon of the composition C_5H_{12} to C_6H_{14}, and is a colorless liquid with a specific gravity between 0.631 and 0.660. Naphtha is employed as a solvent for fats, rubber, and varnish. The petroleum ether used in laboratories is usually the very lightest of the distillate, while that sometimes employed for fuel is the heaviest, and approaches benzine or gasoline. The name naphtha is also applied to various grades of light oils obtained in the distillation of coal tar. These include "solvent naphtha," having a specific gravity of 0.862 to 0.890, with a boiling point below 160 deg. C., and "heavy naphtha," a dark liquid of specific gravity between 0.925 and 0.950, and boiling point betwen 160 and 220 deg. C. The latter naphtha is used in resins and in paints.

Naphtha-sulphonic acid. An acid of the composition $C_{20}H_{20}SO_3H$, produced from mineral oils under German patent 267,785. It is employed in the manufacture of such phenol molding resins as Karbolite.

Natalite. The trade name of an artificial aluminum oxide made in the electric furnace, and used as an abrasive. It is a product of the National Grinding Wheel Company, Inc., Buffalo. See Aluminum oxide.

Natalon. The trade name of a silicon carbide made in the electric furnace, and used as an abrasive. It is a product of the National Grinding Wheel Company, Inc., Buffalo. See Silicon carbide.

Natrundum. The trade name of a silicon carbide used as an abrasive. It is a product of the National Grinding Wheel Company, Inc., Buffalo. See Silicon carbide.

Natumite. The trade name of an artificial corundum used as an abrasive. It is a product of the National Grinding Wheel Company, Inc., Buffalo. See Aluminum oxide.

Naval brass. An alloy sometimes erroneously called naval bronze. It generally contains 60 per cent of copper, 39¼ per cent of zinc, and ¾ per cent of tin. It is one of the regular products of the brass mills, and is employed for articles requiring corrosion-resistant properties. It is yellow in color, tough, and ductile. See also Admiralty metal. United States Navy specifications for naval brass rod call for 59 to 63 per cent of copper, 0.5 to 1.5 per cent of tin, a maximum of 0.06 per cent of iron, and a maximum of 0.20 per cent of lead, the remainder being zinc. This alloy has a tensile strength up to 60,000 lb. per sq. in., and an elongation of 35 per cent in 2 inches.

Neatsfoot oil. A pale-yellow oil obtained by boiling the feet of cattle or sheep in water until all of the oil has risen to the surface. This oil is then skimmed off. The commercial oil is used for leather dressing, or mixed with mineral oils for lubricants. The iodine value is as high as 74, and the saponification value is 197. The specific gravity is 0.916. Neatsfoot oil is valued because of its great resistance to rancidity and oxidation, but it is apt to be extensively adulterated with fish oils, vegetable oils, and mineral oils.

Needle wire. Round tool-steel wire used especially for making needles. It is also employed for making awls and latch pins. It is marketed in coils, in diameter of wire varying by gage sizes from 0.010 to 0.105 inch.

Neon. A rare gas, symbol Ne, which occurs in minute quantities in the atmosphere with helium and argon. It is procured from the air by liquefaction. It is an emitter of light, and is used for sign lighting and in glow lamps. The specific gravity, compared with air, is 0.674. It

liquefies at 243 deg. C. It is colorless, but gives a reddish-orange glow in lamps. Neon is also used in voltage regulating tubes for radio apparatus.

Neutral oils. A trade name for oils obtained by distillation from petroleum without "cracking." Usually, neutral oils are filtered, and will not emulsify in contact with water as do paraffin oils. They are thus considered valuable for use for crank-case lubrication and in circulating systems. "Treated neutrals" are lower in specific gravity than filtered neutrals. All neutral oils are heavier than paraffin oils. They are sometimes "debloomed" by exposing the oil in shallow tanks to weather. This process also bleaches the oil.

Neva-stain steel. The trade name of a non-corrosive steel employed especially for the manufacture of cutlery. It has a high silicon content, and is claimed to forge more readily than ordinary high-chromium steels, and to retain a cutting edge better. It contains 9.5 per cent of chromium, 3.8 per cent of silicon, 0.43 of carbon, and the remainder iron. It is a product of the Ludlum Steel Company.

Newloy. The trade name of an English corrosion-resistant alloy used as a base metal for making tableware. It contains 64 per cent of copper, 35 of nickel, and 1 per cent of tin. See Cupro-nickel.

New Zealand flax. A fiber obtained from the leaves of the New Zealand swamp lily, *Phormium tenax*, also grown in Argentina and some other countries. The fibers have great strength. They are white, soft, and lustrous, and are used largely for cordage. There are two varieties of the plant, one reaching a height of 16 ft., and the other not more than 6 ft. The fibers are obtained by scraping away the woody pulp from the leaves.

Niccolite. A minor ore of the metal nickel. It is a nickel-arsenide, $NiAs$, containing theoretically 43.9 per cent of nickel, usually with a little iron, cobalt, and sulphur.

The mineral occurs massive, with a specific gravity of 7.5, and a hardness of 5 to 5.5. The color is pale copper-red with a metallic luster. It is sometimes called copper-nickel because of its color. Niccolite is found at Cobalt, Canada, and in Germany and Sweden.

Nichroloy. The trade name of a heat-resistant alloy produced by Hiram Walker & Sons Company. It is cast into boxes for use in heat-treating steel parts, and will withstand continuous temperatures up to 2,000 deg. F., without serious deterioration by oxidation. As a casting metal it contains 23 per cent of nickel, 20 of chromium, 1 of manganese, 1 of vanadium, 0.5 of silicon, 0.5 of aluminum, and the balance iron. The grades of Nichroloy used for drawing into resistance wires contain from 40 to 75 per cent of nickel, 7 to 16 per cent of chromium, 3 per cent of manganese, and the balance iron.

Nichrome. The trade name of a group of alloys of nickel and chromium produced by the Driver-Harris Company, and employed for resistance wires in electric heaters, and for furnace boxes for heat-treating steel parts. The standard grade of casting Nichrome for the latter purpose contains 67 per cent of nickel, 16 of chromium, 12 of iron, and 1 of manganese. It has a tensile strength of 64,000 lb. per sq. in., and will resist oxidation for very long periods at temperatures up to 1,800 deg. F. The melting point is 1,350 deg. C. The Nichrome resistance wire contains 60 per cent of nickel, 12 of chromium, 26 of iron, and 2 of manganese. The tensile strength is 100,000 lb. per sq. in., and the resistance is 660 ohms per mil. ft. at 20 deg. C. It resists oxidation indefinitely at temperatures up to 1,650 deg. F. The weight is 0.294 lb. per cu. in. Other grades are also marketed for resistance wire and ribbon. Nichrome IV contains 80 per cent of nickel and 20 per cent of chromium, and resists oxidation at temperatures up to 2,100 deg. F. It is claimed to be made of pure materials, and is for heavy-duty heating apparatus. The tensile strength is 120,000 lb. per sq. in., and the electrical resis-

tivity 620 ohms per mil. ft. The melting point is 1,390 deg. Centigrade.

Nickel. A brilliant silvery-white metal first isolated in 1751, but used in alloy with copper since ancient times. Its ores are sulphides, silicates, and arsenides, the most common being the mineral pyrrhotite. Nickel has a specific gravity of 8.84, melts at 2,646 deg. F., and is magnetic up to 680 deg. F. It is marketed in grains or powder, in electrolitic sheets, blocks, shot, and in malleable forms. The metal is resistant to corrosion and the attacks of most acids except nitric. The tensile strength when cold-rolled exceeds 100,000 lb. per sq. in. Nickel finds its greatest uses in alloys, particularly with copper and steel. With copper and zinc it forms German silver. Nickel steels have high strength and resistance. Nickel is also used in coinage alloys, and in commercial heat-resistant and corrosion-resistant alloys. It is also a constituent of some grades of "white gold." About 90 per cent of the world's nickel production of 40,000 tons annually comes from Ontario, Canada, and most of the remainder from the garnierite ores of New Caledonia. The four standard A.S.T.M. grades of virgin nickel are: Electrolytic, containing 99.5 per cent of nickel; X shot, containing 98.9 per cent; A shot, with 97.75 per cent; and Ingot, with 98.5 per cent. Thirty-seven per cent of the nickel consumption goes into nickel steels, 17 per cent into white metals, and 23 per cent for anodes.

Nickel bronze. A name given to bronzes containing nickel. This metal is added especially to replace part of the tin, and it is claimed to produce a tougher, smoother, and more resistant casting. Some of these alloys contain up to 7 per cent of nickel with 9 per cent of tin.. A nickel-bronze containing 88 per cent of copper, 5 of tin, 5 of nickel, and 2 of zinc gave an ultimate strength of 40,700 lb. per sq. in., and an elongation of 32 per cent in 2 in. The addition of nickel also improves the corrosion and acid-resistant qualities of the alloy. Cupro-nickel alloys containing small amounts of aluminum have also been called nickel bronzes.

A cupro-nickel containing 88 per cent of copper, 10 of nickel and 2 of aluminum is very hard and tough.

Nickel cast iron. A cast iron in which a small amount of nickel has been introduced. Nickel, like silicon, assists the graphite formation and the carbide decomposition, and therefore reduces chill and acts to eliminate hard carbide spots, chilled edges, and mottled areas. About 1 per cent of nickel is claimed to be equivalent to ½ per cent of silicon, but the effect of nickel is progressive, and does not make the iron brittle like silicon. Nickel in amounts of from 0.5 to 10 per cent will progressively harden cast iron. A gray cast iron which would have a Brinell hardness of 174 was raised to 217 by the addition of 0.67 per cent of nickel, and to 269 by 4.59 per cent of nickel. The same iron with 9 per cent of nickel had a Brinell hardness of 350. Chromium, in amounts from 0.10 to 0.50 per cent is often added to nickel cast iron to refine the grain and increase the chilling power. "Wear-resisting castings" contain about 3 per cent of nickel, 1.5 per cent of silicon, and 0.80 to 1.0 per cent of chromium. They have a Brinell hardness of 385, and a tensile strength of 50,000 lb. per sq. inch.

Nickel-chromium alloys. A group of alloys of nickel and chromium employed chiefly as heat-resisting metals, and for resistance wires in electric heating apparatus. An alloy of 80 per cent nickel and 20 per cent chromium is claimed to withstand temperatures up to 2,100 deg. F. without oxidation. Alloys of this nature are generally marketed under various trade names, most of these, however, contain some iron and other elements. See Nichrome, Cromel, Nichroloy, Calorite, Excello, and Heat-resistant alloys.

Nickel-chromium steel. Steel containing both nickel and chromium, usually in a ratio of 2 to 3 parts of nickel to 1 of chromium. The 2-to-1 ratio gives great toughness, and the nickel and chromium are claimed to balance each other in physical effects. The steels are especially suited

for large sections which require heat-treatment, because of the deep and uniform hardening power. Nickel-chromium steel containing 1 to 1.5 per cent of nickel, 0.45 to 0.75 per cent of chromium, and 0.38 to 0.80 per cent of manganese is used throughout the carbon ranges for case-hardened parts and for forgings where high tensile strength and great hardness are required. Steel with from 3 to 5 per cent of nickel, 1.8 to 2.25 per cent of chromium, and 0.30 to 0.40 per cent of carbon is employed for heavy armor plate, while armor-piercing projectiles are made from steel containing 0.50 per cent of nickel, 2.5 per cent of chromium, and 0.50 per cent of carbon. Low nickel-chromium steels, but with more carbon, from 0.60 to 0.70 per cent, are used for drop-forging dies and other tools. An automobile steel used by the General Motors Company containing 1 to 1.5 per cent of nickel, 0.45 to 0.75 per cent of chromium, 0.50 to 0.80 per cent of manganese, and 0.30 to 0.40 per cent of carbon, when heat-treated, has a tensile strength up to 150,000 lb. per sq. in., and an elongation of 15 to 25 per cent in 2 in. Another steel containing 1.5 to 3 per cent of nickel, 0.90 to 1.25 of chromium, and 0.45 to 0.55 of carbon, and used for transmission gears, has a tensile strength of 265,000 lb. per sq. in. All of these steels require special heat-treatment to bring out their best qualities, and in general all of them are difficult to machine. Some nickel-chromium steels are marketed under trade names. See Samson steel.

Nickelene. The name sometimes given to German-silver alloys, containing from 5 to 30 per cent of nickel, 52 to 80 per cent of copper, and from 10 to 35 per cent of zinc. See German silver.

Nickeloy. The trade name of a light aluminum alloy claimed to have great strength. A typical analysis shows a content of 93.8 per cent of aluminum, 4.15 of copper, and 1.41 of nickel, with small amounts of other elements. The tensile strength of the cast metal is 20,000 lb. per sq. in., with an elongation of about 5 per cent in 2 inches.

Nickel-molybdenum steel. An alloy steel which is largely used in compositions of 1.5 per cent of nickel and 0.15 to 0.25 per cent of molybdenum, with varying percentages of carbon up to 0.50 per cent. Molybdenum produces toughness in the steels, and in the case-hardened steel gives a very tough core. Roller bearings are made of this class of steel. See Molybdenum.

Nickel silver. A name applied to the copper-nickel-zinc alloys formerly widely known under the name of German silver. The latter name is now most usually applied in the tableware trade, while the machine industries prefer the designation nickel-silver. "Packfong," meaning "white copper," is an old name for these alloys. Nickel whitens brass, and makes it harder and more resistant to corrosion. But the alloys are more difficult to cast because of more shrinkage and absorption of gases. They are also subject to fire-cracking, and more difficult to roll and draw than brass. The general run of nickel silver contains about 64 per cent of copper, 5 to 25 per cent of nickel, and the balance zinc. It is used for tableware, high-grade plumbing fixtures, automotive trimmings, and electric contact springs. A hard-drawn nickel-silver strip containing 47 per cent of copper, 30 of nickel, and 23 of zinc, has a tensile strength of 130,000 lb. per sq. in., and an elongation of 2 per cent. When annealed it has a tensile strength of 73,000 lb. per sq. in., and an elongation of 32 per cent. The 64 per cent copper, 18 nickel, and 18 zinc alloy has a tensile strength of 94,000 lb. per sq. in. when hard-drawn. The "white nickel brass" used in automotive construction for cast parts for trim contains 55 to 64 per cent of copper, 18 of nickel, and the balance zinc. It is white in color, and has a tensile strength when cast exceeding 30,000 lb. per sq. in. See also German silver, and Cupro-nickel.

Nickel steel. Steel containing nickel as the predominating alloying element. Nickel added to carbon steel increases the ultimate strength, elastic limit, hardness, and tough-

ness. The nickel steels are also of finer structure than ordinary steels. When the percentage of nickel is high the steel is very resistant to corrosion. The percentage of nickel employed usually varies from 1.5 to 5 per cent, with up to 0.80 per cent of manganese. The bulk of nickel steels contain 3½ per cent of nickel. They are used for armor plate, structural shapes, rails, heavy-duty machine parts, gears, automobile parts, and ordnance. The standard A.S.T.M. structural nickel steel used widely for building construction is an open-hearth steel containing not over 3.25 per cent of nickel, 0.45 of carbon, and 0.70 of manganese. This steel has a tensile strength of from 85,000 to 100,000 lb. per sq. in., and a minimum elongation of 18 per cent in 2 in. An automobile steel used by one of the largest companies contains 0.10 to 0.20 per cent of carbon, 3.25 to 3.75 of nickel, 0.30 to 0.60 of manganese, and 0.15 to 0.30 of silicon. When heat-treated it has a tensile strength up to 80,000 lb. per sq. in., and an elongation of 25 to 35 per cent. Very-high-content nickel steels are used where corrosion-resistant properties are required. Standard 3½-per cent and 5-per cent nickel steels are regular products of the mills.

Nickel sulphate. A crystalline compound, $NiSO_4{\cdot}7H_2O$, used in nickel plating, and for blackening brass and zinc. It is prepared by dissolving nickel or nickel hydroxide in sulphuric acid. Nickel sulphate is sold in the form of crystals about the size of peas, and pea-green in color. The specific gravity is 1.98, and the melting point is 100 deg. C. It is soluble in water.

Nickel-tantalum alloy. Nickel containing a percentage of tantalum in alloy. The usual composition is 70 per cent of nickel and 30 of tantalum. The alloy is hard, but is easily rolled or drawn into wire. It is non-magnetic, and does not oxidize when heated to a high temperature. It is prepared by heating at a white heat a highly compressed mixture of the two metals in powdered form, and is not a true alloy, but is formed by diffusion rather than fusion.

The metal is used for electrical resistance wires, or for electrical apparatus.

Niobium. A name sometimes applied to the metal columbium. The symbols Nb and Cb indicating the two names are used interchangably, but the latter is preferred. See Columbium.

Niter. A mineral employed as a source of nitrogen compounds, and in the bluing of steel. It is not as common as soda niter, but is produced in India and from the soils of France and Germany. Niter has the composition KNO_3. It occurs as white crystals of a hardness of 2, and a specific gravity of 2.09 to 2.14. It has a salty taste. "Niter cake" is a distinct substance, and is sodium acid sulphate, $NaHSO_4$. It is used for pickling steel. See Sulphuric acid.

Nitralloy. The trade name of a chromium-aluminum alloy steel which can be surface-hardened by nitration. It is used for making gages and other tools. A typical composition shows 0.45 per cent of carbon, 0.60 of manganese, 1.85 of chromium, 1.29 of aluminum, and very small amounts of silicon, phosphorus, and sulphur. A nitrated hardened case is formed by heating the metal in an ammonia atmosphere to a temperature of about 875 deg. F. for 90 hours and quenching. As the ammonia gas passes through the furnace box it is decomposed and the liberated nitrogen combines with the steel, forming an iron nitride on the outside. The case is hard enough to scratch glass, and is also highly resistant to corrosion. Nitralloy is a product of the Ludlum Steel Company.

Nitric acid. Also called aqua fortis, and azotic acid. A colorless to reddish fuming liquid of the composition HNO_3, having a wide variety of uses for pickling metals, etching, and in the manufacture of nitro-cellulose, pyroxylin plastics, dyestuffs, and explosives. It has a specific gravity of 1.530, boiling point of 86 deg. C., and is soluble in water and in alcohol. Its fumes have a suffocating action, and it is highly corrosive and caustic. Fuming nitric acid is

any water solution containing more than 86 per cent, and having a specific gravity above 1.480. Nitric acid is made by the action of sulphuric acid on sodium nitrate, or purified Chilean saltpeter, and condensation of the fumes. The acid is sold in various grades depending on the amount of water. The strengths of the commercial grades are 38, 40, 42, and 43 deg. Bé. It is usually shipped in glass carboys.

Nitro-cellulose. A compound made by treating cellulose with nitric acid, using sulphuric acid as a catalyst. Since cotton is almost pure cellulose it is the usual raw material. Waste cotton and cotton linters are employed after thoroughly scouring and "digesting" in a weak solution of soda. The cellulose molecule will unite with from 1 to 6 molecules of nitric acid. The weaker compounds are used for the manufacture of rayon, pyroxylin plastics, and lacquers. The higher cellulose nitrates, called guncotton, are employed in making smokeless powders and other explosives. Mono-nitro-cellulose, $C_{12}H_{19}O_9(NO_3)$, contains 3.8 per cent of nitrogen. Trinitro-cellulose, $C_{12}H_{17}O_7(NO_3)_3$, contains 9.13 per cent of nitrogen, and is the product used for celluloid manufacture. It is not detonated by a blow, but the higher compounds are easily exploded. Nitro-cellulose is soluble in most alcohols, ether, and in esters.

Nitrogen. An elementary substance, symbol N, which at ordinary temperatures is an odorless and colorless gas. The atmosphere contains 79 per cent of nitrogen in the free state. It is non-poisonous, and does not support combustion. It can be combined with many metals to form nitrides, and is thus applied to the hardening of steel. The natural nitrates, soda niter and niter, are employed for the making of nitric acid and explosives. Fixation of nitrogen is a term applied to any process whereby nitrogen from the atmosphere is transferred into nitrogen compounds.

Nitro-glycerin. A heavy, oily liquid known chemically as glyceryltrinitrate, and having the empirical formula

$C_3H_5(NO_3)_3$. It is made by the action of nitric acid on glycerin in the presence of sulphuric acid or some other substance having an affinity for water. It is a highly explosive compound, detonating upon concussion. For use as a commercial explosive it is mixed with absorbents and molded into sticks known as dynamite. Nitro-glycerin was first made in 1846. See also Dynamite.

Nitrostarch. An explosive compound made by treating starch with a mixture of nitric and sulphuric acids. It is used for blasting, and as a military explosive it has the advantages of cheapness, insensitiveness to bullet fire, friction, and impact. Dry nitrostarch is highly inflammable, and is treated with inert materials before use. It is a white, finely-divided powder, similar to the original starch. It is insoluble in water. It is readily detonated, and in combinations is employed in trench mortar shells and in grenades. Grenite is nitrostarch mixed with 5 per cent of oil and a binding material. It forms small, white granules, and is used in grenades.

Nixonoid. The trade name of a pyroxylin plastic used for molding a great variety of articles. It is marketed in the form of sheets, rods, and tubes, and is a product of the Nixon Nitration Works, Nixon, N. J. See Pyroxylin.

Nomag. The trade name of an English non-magnetic cast iron, having a high electrical resistivity, and used in electrical construction. It owes its non-magnetic characteristic to the presence of about 6 per cent of manganese. It is made machinable by the addition of about 9 per cent of nickel.

Non-deforming steel. Also called non-shrinking steel. A group of alloy steels which have the characteristic that they do not easily deform, or go out of shape, when heat-treated. This property makes them suitable for making dies, gages, or tools that must be accurate. The older types of non-deforming steel contain from 1.5 to 1.75 per cent of manganese, and 0.15 to 0.25 per cent of vanadium,

with a carbon content of 0.85 to 1.0 per cent. But the newer types contain from 1 to 1.25 per cent of manganese, 0.50 per cent of chromium, 0.50 of tungsten, and sometimes a small amount of vanadium. The carbon content is the same. The phosphorus, sulphur, and silicon impurities are kept as low as possible. These steels are hardened by quenching in oil from a temperature of 1,450 to 1,500 deg. F. The tempering is usually done at 425 to 450 deg. F. The steels are deep hardening, and do not have the tough core of ordinary tool steels. They have low resistance to shock. See also Chromium steel.

Nonpareil insulating brick. The trade name of an insulating brick employed for furnace, kiln, and oven walls. It is a product of the Armstrong Cork and Insulating Company, Pittsburgh. Nonpareil insulating brick is made of kieselguhr, which is pulverized, mixed with finely-ground cork, molded into brick form, and then fired. The cork is burned out, leaving small air pockets to increase the insulating effect. The average heat transmission claimed for temperatures of 500 to 1,500 deg. F. is 0.845 B.t.u., as compared with 0.965 B.t.u. for the natural kieselguhr. The bricks will withstand temperatures up to 1,000 deg. C. without change. The melting point is 1,230 deg. C. Insulating cement under the same name is also marketed for bonding the bricks. An insulating material of kieselguhr under the name of Nonpareil is also sold for the covering of steam pipes. This material does not contain cork.

Novaculite. The trade name of a bluish-white, fine-grained, siliceous stone found in the Hot Springs district, Arkansas, and used as an abrasive oilstone. See Oilstone.

Nuremberg gold. An alloy used in the manufacture of low-priced "gold" articles. Its color is very close to that of gold, and it does not tarnish easily. The average composition is 90 per cent of copper, 7.5 per cent of aluminum, and 2.5 per cent of gold, but it may contain a much higher percentage of aluminum, and also more gold.

Oak. The wood of a large variety of oak trees, all of the natural order *Cupuliferae*, genus *Quercus*. The "She-oak" of Australia, "African oak," and the "Roble," or "oak," of Chile, are not allied to the true oaks. European oak, under various names, such as Austrian oak, and British oak, are from two varieties of the tree *Quercus robur*. The wood is light-brown in color, with a coarse, open grain, firm texture, and weight of about 45 lb. per cu. ft. It is widely distributed in Europe, and the timber is shipped from Riga, Danzig, and other ports. American red oak is from the tree *Quercus rubra*. It is also called black oak. The heart-wood is reddish-brown, and the sap-wood whitish. American white oak is from the tree *Quercus alba*. The heart wood is brown, and the sap-wood white. The grain of these species is coarse, but the texture is firm. Western white oak, *Quercus garryana*, has a more compact texture and straighter grain. American oaks are widely distributed in the United States and Canada. Spanish oak, *Quercus oblongifolia*, is native to California and New Mexico. The grain is finer and denser. Oak is used for flooring, furniture, cask staves, and where a hard, tough wood is needed. For cabinet work the boards are variously sawn at angles and "quarters" to obtain beautiful grain effects. The 1925 production of oak in the United States was 2,129,181,000 board feet. Oak extract, which is an important tanning material for the best grades of heavy leather, is chiefly from the bark of the chestnut-oak, *Quercus prinus*, and from the tan-bark oak, *Quercus densiflora*. The commercial extract contains 25 to 27 per cent of tannin. It is frequently adulterated with chestnut extract.

Oakum. A substance used for caulking the seams of vessels and wooden tanks It consists of old hemp ropes untwisted and pulled into loose fiber, and then treated with tar.

Ochre. A compact form of earth used for paint pigments and as a filler for linoleum. It is an argillaceous and silicious material, often containing compounds of barium or calcium, and owing the yellow, brown, or red colors to hydrated iron

oxides. The tints depend chiefly upon the proportions of silica, white clay, and iron oxide. Ochres are very stable as pigments. They are prepared by careful selection, washing, and grinding in oil. They are inert, and are not affected by light, air, or ordinary gases. They are rarely adulterated because of their cheapness, but are sometimes mixed with other substances to alter the colors. Chinese yellow, and many other names, are applied to the ochres. "Golden ochre" is ochre mixed with chrome yellow. "White ochre" is ordinary clay. A large part of the American ochre is produced in Georgia. Sienna is an ochre found in Italy and Cyprus. Burnt sienna is orange-brown in color, and is made by calcining raw sienna. Indian red and Venetian red are hematite ochres.

Oil asphalt. The heavy, black residue left after removing the tar tailings in the distillation of petroleum. It is a thick fluid, or a solid, depending upon the amount of distillate removed from the crude oil. It contains more than 99 per cent of bitumen, and only about 0.3 per cent of mineral matter, while natural Trinidad asphalt contains only 56 per cent of bitumen, and 37 per cent of mineral matter. Oil asphalt is little affected by water, and does not decay readily. It adheres well to paper, wood, and metals, forming a brilliant surface. It is used for making roofing, and for mixing with natural asphalt for paving, paints, and other uses. It is marketed in steel drums of 400 net pounds each. A gallon of oil asphalt weighs 8.33 pounds. See also Asphalt.

Oilcloth. A fabric of woven cotton, jute, or hemp, heavily coated with turpentine, or paints, and usually ornamented with printed patterns, and varnished. It is employed chiefly as a floor covering, but a light, flexible variety having a foundation of muslin is used as a covering material and for shop aprons. This class comes in plain colors or in printed designs.

Oil gas. Also called carbo-hydrogen. A class of gases produced by allowing petroleum oils to drop on heated

brickwork in a closed retort, or otherwise "cracking" the oil. These gases give a low-temperature flame, and are used for flame cutting torches. They are chemically broken down so that gases containing as high as 85 per cent of hydrogen are obtained commercially in this way. The balance of the gas consists of light hydro-carbons. Oil gas is marketed compressed into steel cylinders of 200-cu. ft. capacity, under a pressure of 1,800 lb. per sq. inch.

Oils. A large group of fatty substances which are divided into three general classes: Vegetable oils, animal oils, and mineral oils. The vegetable oils are either "fixed" or "volatile" oils. The fixed oils are largely glycerides of stearic, oleic, palmitic, and other acids, and they vary in consistency from light fluidity to solid fats. They nearly all boil at 500 to 600 deg. F., decomposing into other compounds. The volatile, or "essential," oils bear distiilation without chemical change. They are derived from plants, and are usually the substances upon which the odoriferous properties of the plants depend. They are soluble in alcohol, ether, or benzol. Oils are found in all plants, particularly in the seeds, and in nearly all parts of animal bodies. Fish oils are thick, with a strong odor. Vegetable and animal oils are obtained by pressing, extraction, or distillation. Oils that absorb oxygen easily and become thick are known as drying oils, and are valued for varnishes, because on drying they form a hard, elastic, waterproof film. Oils and fats are distinguished by consistency only, but waxes are not oils, and upon saponification produce alcohol and fatty oils instead of glycerin. Mineral oils are derived from petroleums. See Petroleum, Quenching oils, Insulating oils, Vegetable oils, Lubricating oils.

Oilskin. A cotton or linen fabric impregnated with oils to make it waterproof. It is used for large sheet coverings for cargo, and for the waterproof coats known as "oilskins." Oiled silk is a thin silk fabric impregnated with boiled linseed oil. It is also waterproof, very pliable, and semi-transparent. It is used for linings.

Oilstone. A fine-grained, slaty silica rock used for sharpening edged tools. The bluish-white, and opaque white oilstones of fine grain from Arkansas are called novaculite, and received their name because they were originally used for razor sharpening. They are composed of 99.5 per cent of chalcedony silica, and are very hard. Novaculite is believed to be a deposit from hot springs. Arkansas oilstones are either hard or soft, and have a waxy luster. They are shipped in large slabs or blocks. Onachita stones come in larger and sounder pieces, but are coarser than the Arkansas. The total production of oilstones in the United States in 1926 was 1,640 short tons. A famous oilstone also comes from Asia Minor.

Oleic acid. Also called red oil, and elaine oil. An organic acid having a complex composition, represented empirically by the formula, $CH_3[(CH_2)_7CH]_2COOH$. It is used in making soluble oils and cutting compounds, in which it forms sodium oleate, $C_{17}H_{33}COONa$. It is also used in the manufacture of oil-soluble colors and of soft soaps. Oleic acid is found in most fats in combination with glycerol, particularly in liquid fats, or oils, such as olive oil, oleo oil, cottonseed oil, and coconut oil. It can be separated from fats by saponification, and is obtained by distillation. It is an oily liquid with a specific gravity of 0.890, boiling point of 222 deg. C., and freezing point of −10 deg. C. It is soluble in alcohol. The two commercial grades of oleic acid are known as "saponified" and "distilled" red oil.

Onyx. A variety of mineral differing from agate only in the straightness of its different layers. It is a chalcedony silica. The alternate bands of color are usually white and black, or white and red. Onyx is artificially colored in the same way as agate. It is used as an ornamental building stone, usually cut into slabs.

Open-hearth steel. Steel made by the process of melting pig iron and steel or iron scrap in a suitably lined regenera-

tive furnace, and boiling the mixture, with the addition of pure lump iron ore, until the carbon is reduced. The boiling is continued for a period of 3 or 4 hours. The process was developed in 1861 by Siemens in England. The furnaces are made in sizes from 10 to 300 tons capacity, and contain regenerative chambers for the circulation and reversal of the gas and air. The fuels used are natural gas, fuel oil, coke-oven gas, or powdered coal. Both the acid- and basic-lined open-hearth furnaces are used, but 80 per cent of all steel made in the United States is basic open hearth. Ganister is used as a lining in the acid furnaces, and magnesite brick in the basic. An advantage of the open-hearth furnace is the ability to handle raw materials that vary greatly, and also to employ scrap. The "duplex" process consists in melting the steel in an acid Bessemer furnace until the silicon, manganese, and part of the carbon have been oxidized, and then transferring to a basic open-hearth furnace where the phosphorus and the remainder of the carbon are removed. This increases the production in a given period. Open-hearth steel is of uniform quality. The open-hearth steel bars used by one of the largest electric manufacturing companies contains 0.08 to 0.18 per cent of carbon, a maximum of 0.55 per cent of manganese, 0.05 of phosphorus, and 0.06 per cent of sulphur.

Optical glass. A highly refined glass, usually a flint glass of special composition, used for lenses and prisms. It is cast, rolled, or pressed. In addition to the regular glass-making elements, silica and soda, optical glass contains barium, boron, and lead. The highly refractory glasses contain abundant lead oxide or barium oxide, and the low refracting glasses contain abundant silica or boron oxide. A requirement of optical glass is transparency and freedom from color. Traces of iron make the glass greenish, while manganese causes a purple tinge. First-quality optical glass should contain a minimum of 99.8 per cent of SiO_2. Besides the control of the chemical composition

of the glass, careful melting is necessary to obtain fine transparency, and then intense polishing. The pouring temperature is about 1,200 deg. C. The largest optical glass lens, 70 in. in diameter, and 11 in. thick, was cast in May, 1927, by the United States Bureau of Standards. After pouring it was allowed 8 months to cool before removing from the mold.

Ore. A metal-bearing mineral from which a metal or metallic compound can be extracted commercially. Earths and rocks containing metals that cannot be extracted at a profit are not rated as ores. Ores are named according to their leading useful metals. The ores may be oxides, sulphides, haloids, or oxygen salts. A few metals also occur native in veins in the minerals.

Oregon pine. A trade name sometimes applied to Douglas fir, which is the wood of the tree *Pseudotsuga douglasii*, of the northwestern part of the United States. Botanically the tree is not a pine, but is allied to the hemlock fir. See Douglas fir.

Orelite. A trade name for an artificial corundum used as an abrasive. It is a product of the Pittsburgh Grinding Wheel Company. See Aluminum oxide.

Orpiment. A mineral used as a pigment. It is an arsenic trisulphide, As_2S_3, containing 39 per cent of sulphur and 61 per cent of arsenic, and is found in Central Europe, Peru, and in Utah. It has a foliated structure, a specific gravity of 3.4, hardness of 1.5 to 2, a resinous luster, and a lemon-yellow color. Artificial arsenic sulphide is now largely substituted for orpiment.

Osmium. A rare metal, symbol Os, having the highest specific gravity, 22.48, and a very high melting point, 4,890 deg. F. Osmium forms a solid-solution alloy with platinum, and has more than double the hardening power on platinum than does iridium, but it volatilizes so readily into the poisonous tetroxide that it is seldom used to replace

iridium in platinum alloys. With iridium, however, it is used as an alloy for fountain-pen tips under the name of osmiridium. Osmium is not affected by the common acids, and is not dissolved by aqua regia. The metal is sold by the troy ounce, a cu. in. of osmium weighing 11.86 troy ounces.

Ounce metal. A copper casting alloy which is a "standard composition metal," neither a brass nor a bronze. It contains 85 per cent of copper, 5 of tin, 5 of zinc, and 5 of lead. It is used as a bearing metal, and for casting valves, carburetor and pump parts, and similar mechanical pieces. It has a tensile strength of 27,000 to 33,000 lb. per sq. in., elongation of 15 to 20 per cent in 2 in., reduction of area of 15 to 20 per cent, Brinell hardness of 50 to 59, specific gravity of 8.6, and weight of 0.31 lb. per cu. in. It casts well and machines easily.

Oxalic acid. An organic acid of the composition $(COOH)_2$ plus water of crystallization, employed as a bleaching agent for leather, cork, wood, shellac, and as a stain remover from fabrics and porcelain. It occurs in colorless crystals with a specific gravity of 1.653, and melting point of 187 deg. C. It is soluble in water and in alcohol. Oxalic acid is obtained by the action of nitric acid on strong alkalis. The acid and its salts are poisonous.

Oxygen. The most important and abundant of the elements. Its chemical symbol is O. It constitutes about 89 per cent of all water, 33 per cent of the earth's crust, and 21 per cent of the atmosphere. It combines readily with all elements except fluorine, helium, and argon. It is a colorless and odorless gas, and can be produced easily by the electrolysis of water. The specific gravity is 1.1056. It liquifies at −113 deg. C. at 59 atmospheres. Liquid oxygen is a pale, steel-blue, transparent, mobile liquid. Oxygen is the least refractive of all gases. It is the only gas capable of supporting respiration, but is harmful if inhaled pure for a long period. In small quantities it is

an exhilerant. Oxygen has many commercial uses, and is marketed in steel cylinders under a pressure of 2,000 lb. per sq. in. The chief use is for oxy-acetylene welding and metal cutting. See Acetylene. Ozone is an allotropic form of oxygen, and is composed of three atoms of oxygen, O_3. It is formed by electric discharges in the air, or during the evaporation of water, particularly of spray in the sea. It has a peculiar odor, which can be detected in 500,000 parts of air. Ozone is a powerful oxidizer, destroying most organic compounds and bleaching vegetable colors. Pure ozone is an irritant poison, producing influenza, but in minute quantities it is purifying and healthful.

Ozokerite. Also called mineral wax. A natural paraffin found in Utah and in Central Europe, and used as a substitute or adulterant of beeswax, and in polishes, phonograph records, and insulation. Ozokerite is a yellowish to black, greasy solid, melting at about 75 deg. C., and having a specific gravity of 0.85 to 0.95. It is soluble in alcohol, benzol and naphtha, but not in water. The wax occurs in rocks, which are crushed, and the wax melted out. The latter is then refined by boiling, treating with an alkali, and filtering. The refined and treated ozokerite is called ceresin. A similar wax, called montan wax, is produced in Saxony from lignite. Ceresin and other mineral waxes are sold in white, waxy cakes.

Paint. A general name to designate a solution of a pigment in water, oil, or organic solvent, and used to cover wood or metal articles either for protection or for appearance. Paints always contain pigments, and the solutions of gums or resins, known as varnishes, are not paints, although their application is usually termed "painting." Enamels and lacquers, in the general sense are under the classification of paints, but specifically the true paints do not contain gums or resins. "Stain" is a trade name for a varnish containing enough pigment to alter the appearance or tone of wood in imitation of another wood. The vast bulk of paint is made with about 65 per cent by weight of pigment

and 35 of vehicle. The best "house paint" for outside work consists of high-grade pigment and linseed oil, with a small percentage of turpentine as a thinner, and a drier. But paints are marketed in an infinite variety of grades, containing pigments adulterated with silica, talc, barytes, gypsum, or other material; fish oils, or inferior semi-drying oils in place of linseed oil; and mineral oils in place of turpentine. Metal paints contain basic pigments such as red lead, ground in linseed oil. Bituminous paints are of coal-tar or asphalt products, dissolved in mineral spirits, and used for the protection of pipes, and for waterproofing cement. Water paints consist of gypsum or whiting with zinc oxide, lithopone, or other material. They are moderate in price, but not durable. Luminous paints are made with radium, mesothorium, or with sulphurated lime. See also Pigments, Drying oils, Driers, Enamels, Lacquers.

Palladium. A rare metal found in the ores of platinum, symbol Pd. It resembles platinum, but is much lighter in weight. The specific gravity is 12.16, and the melting point is 1,549 deg. C. The Brinell hardness of the annealed metal is 49. It is a white metal, and is highly resistant to corrosion and to the action of acids. Like gold, it dissolves in aqua regia. It alloys readily with gold, and is employed in some grades of white gold. It also forms solid solutions with platinum, and the alloys are harder than either of the constituent metals. These alloys are easily workable, and are employed for instruments and jewelry.

Palm oil. An oil obtained from the fleshy covering of the seed nuts of several species of palm trees, chiefly *Elaeis guineensis*, native to tropical Africa. The largest use of the oil is as a fluxing dip in the manufacture of tin plate, but it is also used for soaps, candles, and butter substitutes. Fresh palm oil has an agreeable odor and a bright orange color, but the oil of commerce often has a rancid stench and is of varying colors. Palm oil contains from 50 to 70 per cent of palmitic acid, $C_{16}H_{32}O_2$, which is an ingredient of most fats. The tree attains a height of about 60 ft.,

and the nuts occur in large bunches similar to dates. The fruit is an elongated ellipse shape, about 1½ in. long, enclosing usually a single kernel. The fleshy part carries about 65 per cent of oil, which is a semi-solid fat. The iodine value is about 55, and the saponification value 205. Palm oil for tin-plate dip is sometimes adulterated with cottonseed and mineral oils. See also Hydrogenated oils.

Paper. The name given to cellulose made into paste form from plant sources and rolled into thin sheets, used as a material for writing, printing, and wrapping. There are many varieties and grades of paper, depending upon the source of the cellulose and the method of manufacture. Newsprint and cheap papers are made from wood, but wood is a lignified form of cellulose, and the wood is chipped and cooked with sulphites or other chemicals to dissolve out the lignin. Cotton is nearly pure cellulose, and makes an excellent paper material. Old cotton rags are thus scoured and used for paper making. Linen fabrics are also used, and produce a fine grade of writing paper. To make paper smooth surfaced and resistant to the spreading of inks "sizing" materials such as resins, starch, and glue are used in rolling. Paper is partly waterproofed with a copper-ammonium solution and hot-rolled. Paper is designated by its weight per ream, a ream consisting of 480 sheets, each 24 by 36 inches.

Paper maché. Also known under its full French name of papier maché. Comminuted paper or paper pulp made into a paste with a binder, and molded into any desired form. It is then usually painted, enamelled, or decorated, or is dyed while in the paste form. It was originated in 1740 in Paris, and was widely employed before the invention of celluloid and the synthetic resins. It is now used for toys, dishes, and novelties. It is easy to mold, but it has little strength, and is not suitable for mechanical parts.

Paraffin. A general name often applied to paraffin wax, but more correctly referring to a great group of hydrocar-

bons obtained from petroleum. Paraffin compounds begin with methane, CH_4, and are sometimes called the methane group. The substances in the series have the general formula C_nH_{n+2}, and include the gases methane and ethane, and the products naphtha, benzine, gasoline, lubricating oils, vaseline, and the common paraffin. The name paraffin indicates little affinity for reaction with other substances. In common practice the name is limited to the paraffin waxes that follow vaseline in the distillation of petroleum. These waxes melt at from 48 to 55 deg. C., and consist of the hydrocarbons between C_{22} and C_{27}. They burn readily in the air. Paraffin occurs to some extent in some plant products, but its only commercial source is from natural petroleum.

Paraffin oil. The drip oil from the wax presses in the process of extracting paraffin wax from the wax-bearing distillate in the refining of petroleum. The oil is treated, redistilled, and separated into various grades of lubricating oils from light to heavy. They may be treated and bleached with sulphuric acid, and neutralized with alkali. When decolorized with acid and sold as "filtered," they are brilliant liquids, but are not suitable as crankcase lubricants, or in places where there may be contact with water, since the "sulpho" compounds present cause emulsification. The specific gravities of paraffin oils are between 21 and 26 deg. Baumé.

Paraffin wax. The first distillate taken from petroleum after the cracking process is known as wax-bearing, and is put through a filter press and separated from the oils. The wax collected on the canvas plates is called "slack wax," and contains 50 per cent of wax, and 50 of oil. This is put through a sweating process which frees it from the oil. The sweated wax is separated into different grades with melting points varying from 105 to 136 deg. F. The yellow wax may be melted and filtered through bone dust or fuller's earth to make refined wax, which is colorless, odorless, and tasteless. Paraffin wax is soluble in ether,

benzine, and essential oils. Match wax has a melting point of 105 to 112 deg. F.; white crude wax, 111 to 113 deg. F.; yellow crude, 117 to 119 deg. F.; semi-refined, 122 deg. F.; and special white, 124 to 126 deg. F. The refined waxes are in various melting point ranges from 115 to 132 deg. F. Wax is marketed in barrels, 20-lb. slabs, and cases. It is used for sealing, waterproofing paper, as a filler for leather, and for many other things.

Paraguayan cedar. The wood of the tree *Cedrela braziliensis*, of Paraguay, Brazil, and northern Argentina. It is somewhat similar in appearance to Spanish cedar, but is harder, denser, and redder in color. It seasons well, and does not warp easily. The weight is about 32 lb. per cu. ft. The timber is available in very large logs. It is used for interior building work, and for cabinet work.

Para steel. The trade name of a straight carbon tool steel used for making cutters, dies, taps, and drills. It is a product of the Cyclops Steel Company, Titusville, Pa. It is hardened by quenching in water from a temperature of about 1,450 deg. F. The temper is then drawn as for other carbon tool steels.

Parchment. A very hard and tough paper used for documents. It resists soaking in water, and lasts for long periods. It is made by dipping ordinary heavy cellulose paper into cold, strong sulphuric acid and then washing in water.

Parock. The trade name of an "oil-less" bearing material produced by the Manhattan Rubber Mfg. Company, Pasaic, N. J. It is made up of graphite bonded together with vulcanized rubber, and the percentage of graphite is varied to suit conditions. The crushing strength is 7,000 to 8,000 lb. per sq. in., and the coefficient of friction is 0.095 to 0.140. It is suited for bearings for textile machinery or where it is difficult to lubricate.

Parsons' alloy. One of the earliest forms of "manganese bronze," patented in 1876 by P. M. Parsons. A typical

analysis is: 56 per cent of copper, 41.5 of zinc, 1.20 of iron, 0.70 of tin, 0.10 of manganese, and 0.46 of aluminum. The tensile strength of this alloy is 70,000 lb. per sq. in., elongation 25 per cent, and the Brinell hardness 104 to 119. The specific gravity is 8.4. See Manganese bronze.

Pasteboard. A class of thick paper used chiefly for making boxes and cartons, and for spacing and lining. It may be made by pasting together several single sheets, but more usually by macerating old paper and rolling into heavy sheets. It may also be made of straw, and other inferior paper materials.

Patina. Articles of bronze, or copper-tin alloys, when exposed for a long period to the action of the air acquire a greenish-brown crust known as "patina," which is highly esteemed as a characteristic of antiquity. Ancient statues of bronze are usually coated with patina, which is largely composed of SnO_2, CuO, and PbO, and this is imitated by artificial oxidation on various bronze articles.

Patronite. One of the chief ores of the metal vanadium. It is worked chiefly in Peru, but it also occurs in other places. It is a greenish sulphide of vanadium with approximately the formula V_2S_9, but often associated with pyrites and carbonaceous matter. It has a specific gravity of 2.71, and when calcined loses about 45 per cent of its weight.

Paving sand. A type of commercial sand which is divided into three general classes, that for concrete pavements, for asphaltic pavements, and that for grouting. Sand for concrete pavements, according to the United States Bureau of Public Roads, should all pass through a ¼-in. screen, 5 to 25 per cent should be retained on a No. 10 sieve, from 50 to 90 per cent on a No. 50 sieve, and not more than 10 per cent should pass through a No. 100 sieve. Not more than 3 per cent of the weight should be matter removable by elutriation. For asphaltic pavements small amounts of organic matter are not objectional in the sand. All should pass through a ¼-in. screen, 95 to 100 per cent through a No. 10

sieve, and not more than 5 per cent through a No. 200 sieve. Grouting sand should all pass through a No. 10 sieve, 80 per cent through a No. 20 sieve, and 5 per cent through a No. 200 sieve. The recorded commercial consumption of paving sands in the United States exceeds 20,000,000 tons annually.

Peat. A substance valued as a fuel in countries where other more efficient fuels are expensive. Peat beds, or bogs, are found mainly in moist districts in temperate climates. The peat is an earthy mass formed by the rapid accumulation of quick-growing mosses and plants. The top layers are only slightly decayed, are brown in color, and of low specific gravity. But at greater depths in the ground, peat is nearly black and is very compact. Fresh peat often contains as high as 80 per cent of moisture, and must be dried before use as a fuel. Wicklow dried peat contains about 71 per cent of volatile matter, 27 per cent being fixed carbon, and 28 per cent coke. The calorific value of peat is about 5,000 B.t.u. Peat is sometimes semi-carbonized and made into fuel briquettes. It can be distilled, yielding mainly gas and tar.

Peerless A steel. The trade name of a tungsten alloy steel recommended for use in making hot-heading and forging dies, gripping dies, and swadges. It retains its hardness while hot, and is very tough. It is a product of the Crucible Steel Company of America. The steel is marketed annealed. It is hardened by heating slowly to about 1,500 deg. F., then raising rapidly to from 2,000 to 2,150 deg. F., and either cooling in an air blast or quenching in oil. It is then tempered at about 1,000 deg. F. See High-speed steel.

Pencil cedar. The wood of the tree *Juniperus virginiana*, of the eastern United States, but the name is also applied to the woods of several other species, particularly *Juniperus barbadensia*, and *J. bermudiana*, of the Southern States, and of the West Indies. These woods are almost identical, and are all used chiefly for pencil making. The color is

yellowish to purplish-red, often streaked. The wood is soft and has a regular, even grain. It is very fragrant. The weight is about 34 lb. per cu. ft. African pencil cedar is from the tree *Juniperus procera*, of East Africa. The wood is harder and heavier than American pencil cedar. It weighs 40 lb. per cu. ft., and has a closer texture. It is also less fragrant.

Permalloy. The trade name of an iron-nickel alloy possessing a magnetic susceptibility very much greater than iron. It was developed by H. D. Arnold and G. W. Elmen. Its composition was originally determined by experiment, and it is made up theoretically of 78.5 per cent of nickel, 21.5 per cent of iron, but with other elements approximately as follows: Carbon 0.04 per cent, silicon 0.03 per cent, cobalt 0.37 per cent, copper 0.10 per cent, and manganese 0.022 per cent. It is a product of the Western Electric Company, and is used in the construction of magnetic cores of apparatus that operate on feeble electric currents. It is also used in loading submarine cables. Permalloy has very little magnetic hysteresis, and is not suitable for permanent magnets.

Permanite. The trade name of a permanent magnet steel containing cobalt, chromium, and tungsten. It is claimed to have a coercive force about 50 per cent higher than ordinary tungsten or chromium magnet steels. The name is also used for a pyroxylin plastic used for molding purposes by the Parker Pen Company.

Persimmon wood. The wood of the persimmon tree, *Diospyros virginiana*, of the southeastern United States. It is used for shuttles, golf-stick heads, tools, and it takes a fine polish. The tree belongs to the ebony family. The wood is very hard, strong, and compact. The sap-wood is light-brown in color, and the heart wood is black. The weight is 49 lb. per cu. foot.

Petrolatum. A jelly-like substance obtained in the fractional distillation of petroleum. Its composition is between $C_{17}H_{36}$ and $C_{21}H_{44}$, and it distills off above 303

deg. C. It is also called petroleum jelly. It is used for lubricating purposes. When highly refined it is called vaseline in the pharmacy trade. The specific gravity ranges from 0.820 to 0.865. It is insoluble in water, but readily soluble in benzine and in turpentine. For lubricating purposes it should be refined by filtration only, and not with acids. The melting point should be between 115 and 130 deg. F. It should not be adulterated with paraffin.

Petroleum. A heavy liquid, inflammable, mineral oil stored under the surface of the earth, and probably of ancient marine animal origin. It consists chiefly of carbon and hydrogen. A typical composition is 84.5 per cent of carbon, and 12.5 per cent of hydrogen, with 3 per cent of impurities. In Mexican and Texas petroleum, however, the sulphur alone reaches 3 per cent. The main part of petroleum is formed of hydrocarbons, and consists of most of the liquids of the paraffin series, C_5H_{12} to $C_{16}H_{34}$, together with some of the gases, CH_4 to C_4H_{10}, and most of the solids of the series from $C_{17}H_{36}$ to $C_{27}H_{56}$. It also contains hydrocarbons of other series, and the residue contains sulphur, nitrogen, and oxygen. Petroleums from different localities differ in composition. The crude oil is split by distillation into naphtha, gasoline, kerosene, lubricating oils, paraffin, and asphalt. It may also by split by cracking, that is, by subjecting to violent heating in the absence of air. This process yields a higher proportion of volatile products because of the breaking down of the more complex molecules by the high heat. Petroleum from Baku was used from ancient times for lighting purposes, and the Bolivian oil was used in the sixteenth century for burning. The first commercial wells in the United States were opened in 1859 at Titusville, Pa. The chief producing countries at the present time are Mexico, United States, Mesopotamia, Peru, and Russia, but reserves exist in many other places. The world production of petroleum was 1,096,608,000 barrels in 1926. See also Gasoline, Paraffin, Benzine, Neutral oils, Petrolatum, Fuel oil, Lubricating oils.

Petroleum coke. The final residue of the distillation of petroleum. It forms about 5 per cent, by weight, of the crude oil. After removing from the bottom of the still it is broken up and marketed as "chipped" and "unchipped." The chipped coke has the brown sand and impurity crust removed. Petroleum coke contains about 99 per cent of pure carbon, and is employed for making electric light carbons, carbon points, and "carbons" for various other purposes.

Petroleum ether. The lightest and lowest boiling-point oils distilled from petroleum. It is sometimes equivalent to naphtha, or may even include benzine and some gasoline. The boiling point limits are 40 to 70 deg. C., and the specific gravity 0.631 to 0.660. It may include the hydrocarbons C_5H_{12} to C_6H_{14}, although true petroleum ether should have only the lower limit materials. The A.S.T.M. specifications for "petroleum spirits" call for a water-white liquid, with flash point not lower than 30 deg. C. It is used as a solvent, or for a fuel in lighters.

Petroleum pitch. The final distillate before the coke in the distillation of petroleum. It is a black, tarry product, and is employed for roofing. See Tar.

Pewter. A very old name for tin-lead alloys used for dishes and ornamental articles, but now referring to the use rather than to the composition of the alloy. Tin was the original base metal of the alloy, the ancient Roman pewter having about 70 per cent of tin and 30 of lead, although iron and other elements were present as impurities. Pewter of the sixteenth century contained as high as 90 per cent of tin. Pewter is now likely to contain zinc and antimony, and very much less tin, but when the proportion of tin is below about 65 per cent the alloys are claimed to be unsuited for vessels to contain food products, because of the separation of the poisonous lead. Antimony as an alloying product is also undesirable in food containers because of its poisonous nature.

Phenol. Also known commonly as carbolic acid. A colorless, crystalline substance of the composition C_6H_5OH, obtained from the distillation of coal tar. It is used industrially largely for the production of phenol resins used as molding materials for making mechanical and electrical parts. Phenol melts at about 43 deg. C., boils at 183 deg. C., and dissolves in most organic solvents. The specific gravity is 1.066. By melting the crystals and adding water, "liquid phenol" is produced, which remains liquid at ordinary temperatures. Phenol has the unusual property of penetration of living tissues, and forms a valuable antiseptic. It is poisonous when taken internally.

Phenol-formaldehyde resin. A synthetic resin made by the reaction of phenol and formaldehyde, and employed as a molding material for the making of many mechanical and electrical parts. The reaction was known as early as 1872, but was not utilized commercially until much later. A condensation product of 50 parts of phenol and 30 parts of 40-per cent formaldehyde made under English patent 8,875 of 1905, was called Resinite, and was offered as a substitute for celluloid. An ebonite substitute was made by adding pitch, lampblack, or aniline black. Various modifications were made by other inventors. See Bakelite. "Juvelite" was made in Germany by condensing the phenol and formaldehyde with the aid of mineral acids, while "Laccain" was made under an English patent by using organic acids as catalysts. Phenol-formaldehyde resins are transparent, brittle, soluble in alcohols, but insoluble in water, turpentine or benzol. They are usually mixed with wood flour or other filler, which makes them less expensive and also more plastic and resistant to fracture. They can be easily dyed to any color. "Synthetic amber" is a phenol-formaldehyde resin made more pliable and transparent by the addition of amyl alcohol or glycerol. Phenol resins are marketed under various trade names, such as Bakelite, and Durez.

Phenol resins. Synthetic resins employed for molding compounds, and for making varnishes, cements, and binders. They are condensation products produced by the action of phenol on formaldehyde, hexamine, furfural, or other substances. The most commonly known is the phenol-formaldehyde resin. The phenol resins are marketed usually under trade names such as Bakelite, and Durite. For molding into mechanical and electrical parts they are mixed with wood flour, mica, or some other filler material. To give them flexibility tung oil or some other oil is mixed with them. They can then be punched or sheared. These resins are naturally transparent, but can easily be colored with dyes. They are impervious to moisture, which makes them suitable for electric insulators. See Bakelite, Micarta.

Phenylimino-phosgene. A lachramatory poison used in chemical warfare. It is a liquid of the composition C_6H_5-$NCCl_2$, having a boiling point of 209 deg. C. It is made by a complicated process from carbon bisulphide, milk of lime, and aniline. The poison is thrown in high-explosive shells, and is disseminated as a mist. See also Poison gases.

Phono bronze. The trade name of a group of alloys high in copper, containing small amounts of tin, approximately 1.25 per cent, and fluxed with silicon. They can be hot rolled and forged at 700 to 800 deg. C. They are tough, ductile, and resistant to corrosion. The tensile strength may be as high as 90,000 lb. per sq. in. when drawn into wire. The alloys are used chiefly for trolley wire because of their strength and resistance to atmospheric conditions, although the electrical conductivity is only about half that of copper.

Phoran. The trade name of an abrasive used for grinding very hard materials. It was developed in Germany, and is a tungsten carbide made in the electric furnace. Its melting point is 5,400 deg. F., and it has a hardness of 9.8 to 9.9 on the Moh scale, being nearly equal in hardness to the diamond. See Tungsten carbide, and Abrasives.

Phosgene. The common name for carbonyl chloride. A colorless, extremely poisonous gas of the composition $COCl_2$, made by the action of chlorine on carbon monoxide. It is compressed into a liquid in shells and bombs for use as a lethal poison in chemical warfare. One part in 10,000 parts of air is claimed to be fatal. It has a delayed action on the heart. When chloroform is exposed to light and air it decomposes and forms phosgene. It was discovered by Davy in 1811, and was given the name phosgene, meaning produced by light. Phosgene liquefies at 8.2 deg. C., and solidifies at −118 deg. C. The specific gravity is 1.432 at 0 deg. C. It is soluble in benzene, toluene, and other hydrocarbons. It is decomposed by water. The odor is unpleasant. See also Poison gases, and Lethal gases.

Phosphor bronze. A bronze deoxidized by the addition of phosphorus to the molten metal. It may or may not contain phosphorus in the final state. Ordinary bronze frequently contains cuprous oxide which is formed by the oxidation of the copper during fusion. By the addition of phosphorus, which is a powerful reducing agent, a complete reduction of the oxide takes place, and the resulting bronze has a higher strength. Phosphor bronze is not generally a special alloy, but is a deoxidized bronze, and all grades of bronze can be converted into it. Phosphor bronze can be made by the addition of yellow phosphorus to the molten metal, but usually by the addition of rich phosphor-copper or phosphor-tin. Phosphor bronze does not ordinarily contain more than 0.75 per cent of phosphorus. Its melting point is about the same as ordinary bronze of the same copper-tin composition. Hard-drawn phosphor bronze wire may have a tensile strength exceeding 120,000 lb. per sq. in. In addition to its hardness and high strength it has a low coefficient of friction, and is therefore valued as a material for machine bearings, gears, and worm wheels. See also Standard phosphor bronze, Gear bronze, and Phosphor casting bronze.

Phosphor casting bronze. A bronze used for the casting of bearings and other parts of machines. The composition employed by the General Motors Corporation consists of 80 per cent of copper, 10 of tin, 9.85 of lead, and 0.15 of phosphorus. It casts well, and is especially adapted for bearings under severe loads wearing on hardened steel. The ultimate strength is 25,000 lb. per sq. in., and the elongation in 2 in. is 8 per cent.

Phosphor-copper. An alloy of phosphorus and copper used instead of pure phosphorus in making phosphor bronze. It comes in 5-, 10- and 15-per cent grades, and is added directly to the molten metal. It serves as a powerful deoxidizer, and the phosphorus also hardens the bronze. Phosphor-copper is made by forcing cakes of phosphorus into molten copper and holding under until the reaction ceases. It is usually marketed in slabs notched for breaking into small sections.

Phosphor-tin. A mixture of tin and phosphorus used for adding to molten bronze in the making of phosphor bronze. It usually contains 5 per cent of phosphorus, and should not contain lead. It has an appearance like antimony, with large glittering crystals. It is marketed in slabs.

Phosphorus. A non-metallic element, symbol P, widely diffused in nature, and found in many rock materials, in ores, in the soil, and in parts of animal organisms. Commercial phosphorus is obtained from phosphate rock by reduction in the electric furnace with carbon, or from bones by burning and treating with sulphuric acid. Phosphorus is highly important in metallurgy because of its property of combining and greatly modifying the characteristics of metals, and because of its deoxidizing power, especially in non-ferrous metals. It is added to the latter in the form of phosphor-copper or phosphor-tin. There are two forms of phosphorus, yellow and red. The former is light-yellow in color, semi-transparent, a wax-like solid, phosphorescent in the dark, and exceedingly poisonous. Its specific

gravity is 1.83, and melting point 44 deg. C. It was formerly much used in making matches. Red phosphorus is a reddish-brown amorphous powder, having a specific gravity of 2.296, and a melting point of 725 deg. C. Both forms ignite easily in the air.

Phthalic anhydride. An important intermediate substance in the manufacture of aniline dyes, which has lately been also used for condensing with glycerin to make synthetic resins for molding compounds, and insulating varnishes. It forms white needles, having a composition of $C_6H_4(CO)_2O$, and melting point of 126 deg. C. It is only slightly soluble in water, but is soluble in alcohol. See also Glyptal.

Piano wire. A generally accepted name for a cold-drawn steel wire of high quality, intended for piano strings, but also used for many other purposes in industry. About 90 per cent of the piano wire used in the United States is drawn from Swedish billets or rods. The total production is about 300,000 lb. annually, exclusive of ordinary "music wire." A concert grand piano requires about 3 lb. of wire. Piano wires range in diameter from 0.03 in. to 0.065 in. Starting with No. 7 rod there may be as high as 40 draws before the finished wire is produced. The tensile strength of high-grade piano wire is from 350,000 to 400,000 lb. per sq. inch.

Piassaba. Also called para-grass and monkey-grass. A coarse, stiff, and elastic fiber obtained from a species of palm tree, *Leopoldinia piassaba*, of Brazil, used for making brushes and brooms. The plant has long beards of bristle-like fibers, which are combed out and cut off of the young plants. These fibers sometimes reach a length of 4 feet. The long, fine fibers are made into cordage, and the coarser ones are used for brushes. It is very resistant to water.

Pickling acids. Acids used for "pickling," or cleaning castings, or metal articles of any kind. The common pickling bath for iron and steel is composed of a solution of sulphuric acid and water, 1 part acid to from 5 to 10 parts of water being used. This acid attacks the metal and cleans

it of the oxides and sand by loosening them. Hydrofluoric acid solutions are sometimes used for pickling iron castings. This acid attacks and dissolves away the sand itself. For cleaning brass a mixture of sulphuric acid and nitric acid, in the ratio of 3 to 2, is used. Since all of these acids form salts rapidly by the chemical action with the metal, they must be renewed with frequent additions of fresh acid. The temperature of most pickling solutions is from 140 to 180 deg. F. An increase of 20 deg. F. will double the rate of pickling. "Acid brittleness" after pickling is due to the absorption of hydrogen when the acid acts on iron, and should be reduced by short pickling times. "Inhibitors" are chemicals added to reduce the time of pickling by permitting higher temperatures and stronger solutions.

Picric acid. A high explosive, known also as trinitrophenol, and as melinite by the French. The British explosive lyddite, and the Japanese explosive schimose are both cast picric acid. It is a lemon-yellow crystalline solid of the composition $C_6H_2(OH)(NO_2)_3$, slightly soluble in water, and soluble in alcohol and in benzene. It has a persistent bitter taste. It stains the hair and skin of the workmen. Its property of coloring is utilized, and it is employed commercially as a dyestuff. Due to the fact that picric acid forms dangerous sensitive salts with metals it is not used in the United States as an explosive, but as a raw product in the manufacture of ammonium picrate. Picric acid is one of the most powerful of explosives, being exceeded only by tetryl and trinitro-aniline. Picric acid melts at 248 deg. F. It is made by treating phenol with sulphuric and nitric acids, or can be made directly from benzene. When used in shells the picric acid must be kept from contact with the metal by the use of lacquer or varnish. See also Explosive D.

Pig iron. The iron produced from the first smelting of the ore. The melt of the blast furnace is run off into rectangular molds forming, when cold, ingots called pigs. Pig iron contains small percentages of silicon, sulphur,

manganese, and phosphorus, besides carbon. It is useful only for re-smelting to make cast iron or wrought iron. Pig irons are classified as Bessemer or non-Bessemer according to whether the phosphorus content is above or below 0.10 per cent. There are 5 general grades of pig iron as follows: Low phosphorus, with less than 0.03 per cent, used for making steel for steel castings and for crucible steel making; Bessemer, with less than 0.10 per cent of phosphorus, used for Bessemer steel and for acid open-hearth steel; malleable, with less than 0.20 per cent, used for making malleable iron; foundry and basic, with less than 1.0 per cent, for cast iron, and for basic open-hearth steel; and basic-Bessemer, with from 2 to 3 per cent, used for making steel by the basic Bessemer process. The world production of pig iron in 1927 was 84,790,000 gross tons, of which 36,350,000 were produced in the United States and 12,850,000 in Germany. See also Charcoal iron, Puddling iron, Basic pig iron.

Pigment. A substance, usually earthy or clayey, which when mixed with oil or other solvent forms a paint. Pigments usually give body as well as color to the paint. They are mostly of mineral origin, the vegetable pigments such as logwood, and the animal pigments such as cochineal, being ordinarily classified as dyestuffs. Bone black, however, is an example of an animal pigment, and vine black is a typical vegetable pigment. Pigments are also produced by dyeing clays with aniline dyestuffs. Natural pigments include ochre, umber, ground shale, hematite, and sienna. White lead, bismuth oxychloride, blanc fixe, ultra-marine, and antimony red are examples of mineral pigments. Pigments should be ground so fine that the powder will pass through a 325-mesh screen. See also Lead pigments, Ferric oxide, Vermillion red, Lithopone, Zinc white.

Pinchbeck metal. A brass alloy used for making articles of cheap jewelry. It contains from 88 to 94 per cent of copper, and from 6 to 12 per cent of zinc. It has a dark golden color, and is very ductile.

Pine. The wood of various species of trees of the genus *Pinus*. The white pine, *Pinus strobus*, grows widely in Canada and in the northeastern United States. The trees are 80 to 100 ft. high, with trunks 3 to 9 ft. in diameter. The wood is soft, white, straight-grained, and free from rosin. It is the chief wood for pattern making, and is also extensively used for cabinet work and general carpentry. Yellow pine is a name for the wood of the longleaf pine tree, *Pinus palustris*, of the Southeastern States, and shortleaf pine, *Pinus echinata*, of the Southeast and Middle-Western States. The longleaf pine tree furnishes the best grades of yellow pine, and also yields turpentine. Pitch pine, from the tree *Pinus cubensis*, growing along the southern coasts of the United States, is also a form of yellow pine. Loblolly pine, *Pinus taeda*, is also called North Carolina pine and pitch pine. It grows throughout the Southern States. The yellow pines are harder and more difficult to work than white pine. They are resinous and more durable. They also take a better polish, and show a more figured grain. They are valued for flooring and for general construction. All yellow pines are called pitch pine in the export trade.

Pine oil. A turpentine oil obtained from the wood of the *Pinus palustris*, or longleaf pine, in the steam extraction of wood turpentine. It is used as a cold solvent for varnish gums, and for nitro-cellulose lacquers. It will not precipitate the latter from solution in amyl acetate. It is also used in metal polishes. When free from water, pine oil has a yellowish color, but is water-white when it contains dissolved water. It has an aromatic, characteristic odor. It is entirely distinct from the pine oils distilled from pine leaves and needles and used in medicine.

Pitch pine. The wood of the coniferous tree *Pinus taeda*, growing in the Southeastern States of the United States. It is also called North Carolina pine. The wood is hard, resinous, heavy and strong. The grain is wavy, and when polished is considered an excellent flooring material. In the export trade all of the yellow pines are

known as pitch pine. See Pine. The word "pitch" is sometimes used to designate the tar produced from the pine tree. See Tar.

Plane-wood. The wood of the plane tree, *Platanus orientalis*, native to Europe, and *Platanus occidentalis*, of North America. The latter species is also called buttonwood and buttonball. It is a yellowish, compact wood with a fine, open grain. The weight is about 40 lb. per cu. ft. The wood resembles maple, and presents a beautiful grain when quartered. It is employed for cabinet work.

Plaster board. Sheets or slabs consisting of gypsum or some other incombustible substance intimately mixed with about 15 per cent of fiber, and employed for ceilings, partitions, or walls. It may also be made up of a core of gypsum surfaced with paper or fibrous material, and designed to be coated with gypsum after being erected in place. Standard specifications for gypsum boards call for thicknesses of ¼, 5⁄16, ⅜, and ½ in., with usual surface dimensions of 24 × 32 in. The weight of gypsum plaster board ¼ in. thick is 1,200 lb. per 1,000 sq. feet.

Plaster of paris. A soft white powder, which when mixed with water forms a paste that can be molded and will harden into a solid mass. It is used for making casts, and in cements and plasters. It is made by heating gypsum at about 110 deg. C., forming the hemi-hydrate $2CaSO_4 \cdot H_2O$. This product constitutes plaster of paris, which when mixed with water again forms the hydrated sulphate that will solidify and set due to interlocking crystallization. Owing to its solubility in water plaster of paris cannot be used for outside work. See Gypsum.

Plastic bronze. A name applied by makers of bearing bronzes to copper alloys that are "plastic" enough to assume the shape of the shaft and make a good bearing by "running in." These so-called bronzes may have a wide variety of compositions, but the plasticity is always obtained by the addition of lead, which in turn weakens the bearing. In

some cases the lead content is so high, and the tin content so low, that the alloy is in no wise a bronze. The true bearing bronzes are essentially copper-tin alloys, with only small quantities of other metals, and they gain their bearing qualities from the mixture of hard and soft crystals. However, these must be machined more accurately than the plastic bronzes. A typical better grade of "plastic bronze," contains 64 per cent of copper, 30 of lead, 5 of tin, and 1 per cent of nickel. See Bronze.

Plate glass. The trade name for any glass that has been cast or rolled into a sheet, and then ground and polished. But the good grades of plate glass are, next to optical glass, the most carefully prepared and the most perfect of all the commercial glasses. It generally contains slightly less calcium oxide and slightly more sodium oxide than window glass. A typical batch formula is: Sand, SiO_2, 1,000 lb.; limestone, CaO, 320 lb.; soda ash, Na_2O, 310 lb.; salt cake, 65 lb.; and charcoal 3 lb. Small quantities of iron and aluminum oxides are also always present as impurities. The glass is melted in open pots, averaging 2,000 lb. of glass. The melting and refining takes about 20 hrs., and the glass is then poured on the casting table at 1,000 deg. C. The roller is drawn over the plastic glass. After annealing, the sheets, which are usually 14 by 24 ft., are set in plaster of Paris on a circular rotating table and ground with iron blocks and sand. Plate glass comprises about one-fifth of the production of the entire glass making industry, and one-half of the product is used for automobiles.

Platinite. The trade name of an alloy containing 46 per cent of nickel and 54 per cent of iron. Its coefficient of expansion is claimed to be as low as that of platinum, or the same as that of glass. It is used for leads in electric light bulbs in place of platinum. It is resistant to oxidation even at high temperatures.

Platinum. A whitish-gray metal, symbol Pt. It is more ductile than silver, gold, or copper, and is heavier than

gold. The melting point is 3,190 deg. F., and the specific gravity is 21.40. The hardness of the annealed metal is 47 Brinell. It resists the action of alkalies and most acids, dissolving only in hot aqua regia. Platinum occurs native in small flat grains or pebbles, usually alloyed with iridium, rhodium, palladium, osmium, and ruthenium. The largest nugget ever found came from South America, and weighed 2 lb. It is also found in the mineral sperrylite. The chief sources are Russia and Colombia, with smaller amounts from Canada and South Africa. The world production is about 170,000 oz. annually, of which more than 100,000 oz. come from Russia. The Russian platinum is all refined locally, and is from 99.80 to 99.90 per cent pure, with 0.05 to 0.10 per cent of iridium. It surpasses gold in value, and is rated as a precious metal. It is employed for electric contact points, resistance wires, thermo-couple wires, standard weights, and for vessels for laboratory use. It is also widely used in jewelry. It is too soft for use alone, however, and is almost always alloyed with other harder metals of the same group, such as iridium and osmium. Platinum is sold by the troy ounce, a cu. in. of the metal weighing 11.28 troy ounces.

Platinum-iridium alloys. The most widely used of the platinum alloys. They are employed for instruments, magneto contacts, and jewelry. The alloys are very hard and tough, and are non-corrosive. An alloy of 5 per cent iridium and 95 per cent of platinum, when hard-worked, has a Brinell hardness of 170, while an alloy containing 30 per cent of iridium has a hardness of 400. The 5 and 10 per cent alloys are used for jewelry manufacture, while the 25 and 30 per cent alloys are employed for making surgical instruments. The addition of iridium does not alter the color of the platinum. The 5 per cent alloy dissolves readily in aqua regia, but the 30 per cent alloy dissolves very slowly.

Plumbers' solder. Common, commercial lead solder, frequently referred to as "half-and-half" although the propor-

tions of tin and lead are seldom equal. The usual amount of tin is from 30 to 40 per cent, often with from 2 to 3 per cent of antimony, and the remainder lead. Half-and-half solder, containing 50 per cent tin and 50 per cent lead, will melt at 401 deg. F. "Wiping solder," containing 60 per cent lead and 40 per cent tin, melts at 446 deg. F. "Slicker solder" contains 34 per cent of lead and 66 per cent of tin, and melts at 356 deg. F. It is the tin-lead solder with the lowest melting point.

Plush. A general name for fabrics woven of cotton, silk, linen, or wool, and having a pile deeper than that of velvet. It is used for upholstery work. Originally the pile of plush consisted of mohair or worsted yarns, but there is now no distinction except in the length of the pile. Upholstery plush is sometimes made in brocade designs by burning the pile with rollers to form a lower background. Plush is also dyed and curled to imitate furs.

Plymetl. The trade name of a composite construction board, consisting of a core of laminated wood with galvanized steel faces cemented to it. It is used for sheathing, especially for car and autobus sides, and also for built-up girders. The plates can be riveted. Plymetl has the advantage of greater strength than wood, and is lighter than metal. It is also a heat insulator. It is a product of the Haskelite Manufacturing Corporation, Chicago.

Poison gases. Substances employed in chemical warfare for disabling men, and in some cases used industrially as fumigants. They are all popularly called gases, but the greater proportion are liquids or solids. They are classified into groups according to their main effect on the human system, but one gas may have several effects. The war gases are grouped as follows: Lethal, intended to kill, such as phosgene; lachramators, which affect the eyes, such as chloropicrin; vesicants, or skin blisterers, such as lewisite and mustard gas; stermutatory, which induce sneezing and force the removal of gas masks, such as

diphenyl-chloroarsine; and camoflage, which are harmless, but by their odor cause soldiers to suffer the inconvenience of wearing gas masks and thus reduce their morale. The use of poison gases in warfare was many times proposed, but they were not formally used until adopted by the Germans in April, 1915, although hot pitch and oils had been used since ancient times. War gases are more destructive to morale than to life, as it is extremely difficult to obtain a gas cloud of sufficient toxic power. After August, 1916, gas was distributed only by shells from artillery or by bombs from airplanes. See Lethal gases, and Tear gas.

Pollopas. The trade name of an organic glass made from urea and formaldehyde. It is an Austrian product. Pollopas is transparent, has high surface brilliancy, and does not splinter when it breaks. Its specific gravity is 1.44, or about one-half that of glass. Its refractive index is between 1.54 and 1.90. Pollopas is elastic. It does not melt on heating, but chars at about 200 deg. C. It is transparent to ultra-violet rays, which do not pass through ordinary glass. Its hardness is about 3 on the Moh scale, and it can be turned, drilled, or polished. It has the disadvantage, however, that it is doubly refractive.

Pontianak. A gum from several species of the tree *Dyera*, of Borneo. The commercial pontianak is a grayish-white mass like burnt lime, and contains 60 per cent of water, with only 10 to 25 per cent of rubber-like material. It is used in the friction compounds employed for coating canvas transmission belting, and for adulterating gutta percha. During periods of high rubber prices the rubber content of pontianak has been extracted as a substitute for true rubber.

Poplar. The wood of several species of the tree *Populus*. The "black poplar," *Populus nigra*, of Europe, is a large tree with blackish bark. The wood is yellowish-white with a fine, open grain. It is soft and easy to work. The weight is about 35 lb. per cu. ft. It is used for panelling, packing cases, carpentry, and paper pulp. It is also used

for inlay work. This wood is also called English poplar. Cottonwood is another species of poplar. See Cottonwood. Gray poplar is from the tree *Populus canesceus*, of Europe. The color of the wood is light yellow. It has a tough, close texture somewhat resembling that of maple. It is used for carpentry and flooring. The wood of the "canary whitewood" is called Virginia poplar, or simply poplar, but belongs to an entirely different family of trees. See Canary whitewood. The Aspen is another form of poplar. See Aspen.

Portland cement. The best known and most generally useful of the construction cements. It is a bluish-gray powder obtained by finely grinding the clinker obtained by heating strongly an intimate mixture of calcareous and argillaceous materials. The raw materials are sandy limestone, chalk marl, clay shale, or blast furnace slag, and the mixture should be finely divided and contain about 75 per cent of calcium carbonate and the remainder largely aluminum silicate and free silica. The raw materials are ground either wet or dry. Special furnaces are employed for burning, and the temperature is about 1,500 deg. C. The clinker must be neither under burned nor over burned. The color of the cement is due to iron oxides. A brownish tinge indicates either an excess of clay, or under burning. In the absence of impurities portland cement would be white. The specific gravity is at least 3.10. The tensile strength of good neat cement after 7 days setting should be 500 to 700 lb. per sq. in., and should increase with age. The initial set should not develop in less than 1 hr. The gradual increase in strength of cement is due to the hydration of the tricalcium aluminate and silicates. Portland cement is always used with sand. "Non-staining" cements, are those free from perceptable amounts of iron oxide. Portland cement is sold in 94-lb. cloth or paper bags of 1 cu. ft. capacity, 4 to the barrel. "High-speed" portland cements usually contain high percentages of alumina, and are more costly than ordinary grades.

Port Orford cedar. Known in England under the name of Lawson cypress. The wood of the tree *Cupressus lawsoniana*, of California and Oregon. The tree is of the same genus as yellow cedar. The wood is light yellow in color, straight grained, and glossy. It is somewhat gummy and difficult to plane smooth. The weight is about 34 lb. per cu. ft. It has an agreeable, aromatic odor. It is very durable. The logs are obtainable in great lengths, and up to 10 ft. in diameter. It is a general construction wood.

Potassium. An elementary metal, symbol K, also known as kalium. It is silvery-white in color, but oxidizes rapidly in the air and must be kept submerged in ether or kerosene. It has a low melting point, 63.5 deg. C., and a boiling point at 757 deg. C. The specific gravity is 0.862. It is soluble in alcohol and in acids. It decomposes water with great violence. Potassium is obtained by the electrolysis of potassium chloride. It has no commercial applications, but potassium compounds are widely employed.

Potassium amalgam. A compound obtained by the introduction of potassium into heated mercury, or by mixing sodium amalgam into potash. It is a true chemical compound, having the formula $Hg_{24}K_2$, but is decomposed easily, and is only used for amalgamating with other metals.

Potassium chlorate. A white crystalline powder, or lustrous crystalline substance of the composition $KClO_3$, employed in the manufacture of explosives. It melts at 357 deg. C., and decomposes at 400 deg. C. with the rapid evolution of oxygen. It is odorless, but has a slightly bitter saline taste. The specific gravity is 2.337. Potassium chlorate is not hygroscopic, and does not alter on exposure to the air. It is however, soluble in water, but insoluble in alcohol. It imparts a violet color to the flame when used in pyrotechnic compositions. It is made by the electrolysis of potassium chloride solutions. See Prométhée, and Sprengle explosives.

Potassium chloride. A colorless or white crystalline substance of the composition KCl, used in the machine shop for molten salt baths for the heat-treatment of steels. The specific gravity is 1.987. A bath composed of 3 parts of potassium chloride and 2 of barium chloride is used for hardening carbon-steel drills and other tools. Steel tools heated in this bath and quenched in a 3-per cent sulphuric acid solution have a very bright surface. A common bath is made up of potassium chloride and common salt, and can be used for temperatures up to 900 deg. Centigrade.

Potassium cyanide. A white amorphous or crystalline mass of the composition KCN, employed for carbonizing steel for casehardening, and for electroplating. The specific gravity is 1.52, and it melts at about 1,550 deg. F. It is soluble in water, and is extremely poisonous, giving off the deadly hydrocyanic acid gas. For "cyaniding" steel the latter is immersed in a bath of molten cyanide, and then quenched in water, or the cyanide is rubbed on the red-hot steel. For this use, however, sodium cyanide is usually preferred, because of its lower cost, and the higher content of CN in the latter. Potassium ferro-cyanide, or "yellow prussiate of potash," can also be used for casehardening steel. It has the composition $K_4Fe(CN)_6$, and comes in yellow crystals or powder. The nitrogen as well as the carbon enters the steel to form the hard case. Commercial potassium cyanide is likely to contain a large proportion of sodium cyanide.

Potassium nitrate. Also called niter, and saltpeter. A substance of the composition KNO_3, used in explosives, and for bluing steel. A mixture of 2 parts of potassium nitrate and 3 of sodium nitrate is used for steel tempering baths. The mixture melts at 250 deg. C. Potassium nitrate is made by the action of potassium chloride on sodium nitrate, or Chile saltpeter. It occurs in colorless, prismatic crystals, or as a crystalline white powder. The commercial product is slightly yellow due to impurities.

It has a sharp saline taste, and is soluble in water. The specific gravity is 2.1, and melting point is 337 deg. C. It is found in nature in limited quantities in the alkali region of western United States, and deposits in India and Ceylon are also worked. Potassium nitrate is used chiefly for making gunpowder. As it contains a large percentage of oxygen which is readily given up it is well adapted for pyrotechnic compounds. It gives a beautiful violet flame color in burning. Another use is in smoke-tracer compounds with sulphur and arsenic, and in flares and smoke torches. Its function is to furnish oxygen in concentrated form.

Potters' flint. A finely ground flint used chiefly for mixing with porcelain to reduce the firing and drying shrinkage, and to give body rigidity to prevent deformation. It is also used in enamel mixtures. The requirements are that it be a good white, all pass a 140-mesh sieve, and contain no iron oxide. All true potters' flint is ground from pebbles imported from France. The pebbles are gathered on the sea beaches, and are derived from the weathering of the chalk cliffs. They contain 99 per cent of silica.

Pounce. Originally "pounce" was ground sandarac gum, employed for rubbing on tracing cloth or on paper to prevent ink from spreading or sinking in. But the name is extensively applied to fine powdered pumice used for rubbing down tracing cloth and parchment. See Pumice, and Sandarac.

Pozzuolana cement. A volcanic material found near Pozzuoli, Italy, and in several other places in Europe, and employed as a building cement. It is a volcanic lava modified by steam or gases so that it is powdery and has acquired hydraulic properties. The chief components are silica and alumina, and the color varies greatly, being white, yellow, brown, or black. The crude material is screened and ground. It has been employed as a construction

cement since ancient times. "Trass" is a similar material found in the Rhine district of Germany. "Santorin" is a light-gray volcanic ash with somewhat similar characteristics from the Greek Island of Santorin.

Prométhée. The trade name of a French chlorate explosive in which the chlorate has been made less sensitive by separating it from the combustible matter. In this explosive the oxygen carrier contains 95 per cent of potassium chlorate and 5 of manganese dioxide, and the combustible contains 50 per cent of nitrobenzene, 20 of turpentine, and 30 of naphtha. The final mixture is composed of 87 to 92 per cent of oxygen carrier and 8 to 13 per cent of combustible material. Prométhée is used in the form of compressed cartridges, but is extremely sensitive and dangerous, and will explode by friction. It is now only used when it is desired to economize in the use of nitrates. See also Rack-a-rock.

Proplatinum. The trade name of a white alloy used as a substitute for platinum. A typical analysis shows a content of 72 per cent nickel, 23.6 per cent of silver, 3.7 per cent of bismuth, and 0.7 per cent of gold.

Proustite. An ore of the metal silver, occurring in silver veins associated with other metals. It is found in the mines of Peru, Mexico, Chile, and in Nevada and Colorado. It is also called light ruby silver, and is a sulpharsenite of silver of the composition Ag_3AsS_3, containing theoretically 65.4 per cent of silver. It commonly occurs massive, compact, in disseminated grains. The hardness is 2 to 2.5, specific gravity 5.55, and the color is ruby-red with an adamantine luster.

Prystal. The trade name of a French molding material used for making mechanical and electrical parts, ornamental articles, and non-shattering glass. It is made by the reaction of urea and formaldehyde. It is naturally colorless, but is colored to many shades by dyes. The refractive index is 1.5548, or about the same as that of quartz, but it

has a double refraction and is not suitable for lenses. It is a product of the Societé Industrielle du Celluloid. A similar "organic glass," made from urea by the Luco Products Corporation, Brooklyn, N. Y., is marketed under the name of Aldur. It transmits ultra-violet light and absorbs the infra-red rays. It is also a good insulator. It chars at about 250 deg. C., but does not burn.

Puddling iron. A grade of pig iron used for making wrought or puddled iron by remelting in a puddling furnace. A requirement is that the pig be low in silicon, and preferably contain 0.50 to 1.0 per cent manganese. Any class of pig iron that meets these specifications is claimed to puddle well.

Pulpstones. Large blocks of sandstone cut into wheels and used for grinding, chiefly for the grinding of wood pulp in paper manufacture. The American pulpstones are produced in eastern Ohio and northern West Virginia. The sandstone required for pulpstones must be uniform in texture, have sharp grains, medium hardness, and be composed of even grains of which 85 per cent will be retained on a 150-mesh screen, and 90 per cent on a 200-mesh screen. The cementing material may be siliceous, calcareous, or argillaceous, but must be firm enough to hold the stone together when working under pressure, and soft enough to wear faster than the quartz grains and prevent glazing. The standard diameter of pulpstones is 54 in., and the common width of face is 54 in. The stones are aged or seasoned from 1 to 2 years before use. Aging is sometimes quickened to 1 or 2 months by first heating the stones to about 180 deg. F., in a closed room and cooling slowly. In 1926 the production of pulpstones in the United States was 9,670 tons. See also Grindstones, and Sandstone.

Pumice. A porous, froth-like volcanic glass which did not crystallize due to rapid cooling, and frothed with the sudden release of dissolved gases. Obsedian, or volcanic glass, when melted, will change into pumice. Powdered pumice is used commercially as an abrasive for fine-polishing

of many materials. It is also used in metal polishes. In very fine powdered form it is called pounce, and is used for preparing parchment and tracing cloth. Pumice is grayish-white in color, and the fine powder will float on the surface of water. The production of pumice in the United States in 1927 was 53,298 short tons.

Purple-cut steel. The trade name of a special alloy tool steel containing molybdenum, with silicon as a stabilizer. It also contains chromium, and a high percentage of carbon. It is of the "non-shrinking" type of steel, and is used for taps and dies. It will also maintain a keen cutting edge when cutting at a purple heat. It is forged at a temperature of from 1,700 to 1,900 deg. F., and hardened by quenching in oil from a temperature of 1,525 to 1,825 deg. F. It is then "drawn" at about 500 deg. F. for tools. It is a product of the Ludlum Steel Company.

Purpleheart. The wood of several species of trees of the genus *Copaifera*, of the natural order of *Leguminoseae*, native to tropical South America. The color of the wood is brown, the heart wood turning purple on exposure. The grain is open and fine. The wood weighs about 53 lb. per cu. ft., is very hard, strong and durable. It is used for machine and implement parts, and turnery. The timber is available in very large logs.

Putty. A mixture of calcium carbonate with about 18 per cent of linseed oil, with sometimes white lead added. It is used for cementing window glass in place, and also as a filler for patterns. "Putty powder" is a mixture of lead and tin oxides, used in enamelling and for polishing stone and glass.

Pyralin. The trade name of a pyroxylin plastic used as a molding material for mechanical, electrical, and ornamental articles, and for making non-shatterable glass. It is marketed in sheets, rods, and tubes, and is a product of the Du Pont Viscoloid Company, New York. See also Pyroxylin, and Duplate.

Pyrargyrite. An ore of silver, known also as dark ruby silver. It is a sulph-antimonite of silver, Ag_3SbS_3, containing 22.3 per cent of antimony and 59.8 per cent of silver. It is found in various parts of Europe, in Mexico, and in Colorado, Nevada, and New Mexico. It occurs in crystals or massive, and also in grains. Its hardness is 2.5, and specific gravity 5.85. The color is dark red to black, showing ruby-red in thin splinters.

Pyrasteel. The trade name of a heat-resistant alloy employed for carbonizing boxes, furnace linings, and grids. It is a product of the Chicago Steel Foundry Company. See Heat-resistant alloys.

Pyrogen. The trade name of a gas obtained during the process of recovering gasoline from natural gas. It is used for flame cutting torches, and is marketed in steel cylinders under high pressure.

Pyrolusite. The most important manganese ore. It is mined in various parts of Europe, Australia, Japan, Brazil, Argentina, Canada, and the United States. It is a manganese dioxide, MnO_2. It has an iron-black color, with a metallic luster, and a radiating columnar structure. Its specific gravity is 4.75 and hardness 2 to 2.5. Besides its use as a source of the metal manganese, pyrolusite is used as a dryer in paints, a decolorizer in glass, and in electric batteries.

Pyrope. One of the six varieties of common garnet, used as an abrasive coating for paper and cloth. The color is deep red to nearly black, and the hardness is 6.5 to 7.5. The composition of pyrope is $Mg_3Al_2(SiO_4)_3$. The crystals are sometimes transparent, and are then used as gemstones.

Pyrophoric alloy. A sparking metal used for gas and cigarette lighters. The first patent for a pyrophoric alloy was obtained in 1903 by Auer von Welsbach, German patent 154,807. See Auer metal, and Kunheim metal. A French pyrophoric alloy, French patent 419,388, contains

10 per cent of manganese and antimony, up to 20 per cent of chromium, and up to 15 per cent of titanium.

Pyrophyllite. An aluminum silicate mineral, quarried chiefly in North Carolina, and used as a substitute for talc. Its composition is $H_2Al_2(SiO_3)_4$, and it is almost identical to talc in structure and appearance. Its hardness is 1 to 2, and specific gravity is about 2.8. The color is white, gray, or brown. It has a pearly to greasy luster, and a greasy feel. Compact varieties of the mineral are made into slate pencils and crayons.

Pyroxylin. A compound consisting of nitro-cellulose in a chemical solvent, and used for making celluloid, rayon, collodion, picture films, lacquers, artificial leather, and waterproof fabrics. The usual solvents are ether, fusel oil, ethyl acetate, and amyl acetate. Pyroxylin is colorless to amber colored. It burns readily, but is not dangerously explosive. See Nitro-cellulose. Pyroxylin lacquers and finishes are sold under various trade names such as Duco, Zapon, and Arcozon, and are quick drying because of the volatile type of solvent. They contain inert pigments, and sometimes vegetable oils to lengthen the drying time. Pyroxylin finishes are much used for automobile bodies. They withstand heat and cold, grease, or alkalis, but are not suitable in contact with alcohol. "Pyroxylin plastics" are special compounds for the molding of mechanical and electrical parts. They may contain filler materials. See also Cellulose acetate.

Pyrrholite. Also called magnetic pyrites. An important ore of nickel, found at Sudbury, Canada. It is also found in Norway, Sweden, and in Vermont and Tennessee. Pyrrholite is a sulphide of iron, of the approximate formula $Fe_{11}S_{12}$, but it often carries a small amount of nickel in which case it becomes an ore of that metal. Its hardness is 4, and specific gravity 4.65. The color is brownish-bronze, with a metallic luster.

Q-Alloys. A series of nickel-chromium alloys manufactured by the General Alloys Company. A typical composition is 68 per cent of nickel, 20 per cent chromium, and small quantities of silicon, aluminum, and iron. They are of the class of heat-resistant alloys, and a tensile strength of 27,000 lb. per sq. in. is claimed at a temperature of 1,750 deg. F. The alloys are usually cast into boxes for high-temperature work, but the metal is also furnished in sheet form, and in bars, and can be fabricated by welding. Q-alloys will withstand temperatures up to 2,200 deg. F. without scaling. They can be cast into intricate shapes. The color is silvery gray.

Quality steel. The trade name of nickel-chromium air-hardening steels, especially recommended for gears, and marketed by Quality Steels, Ltd., London, England. They contain from 1.2 to 1.5 per cent of chromium, 4.5 to 5 per cent of nickel, 0.3 to 0.5 of manganese, 0.30 to 0.35 of carbon, a maximum of 0.3 per cent of silicon, 0.025 of phosphorous, and 0.03 of sulphur. The tensile strength is 113 tons per sq. in., elongation 15 per cent in 2 in., and reduction in area 45 per cent.

Quartz. The most common variety of silica, SiO_2. It occurs mostly in grains or in masses of a white or gray color, but often colored by impurities. Pure quartz is colorless, and is called rock crystal. Quartz usually crystallizes in hexagonal prisms or hexagonal pyramids. The grains in sand are often less than 0.04 in., but crystals up to 20 in. have been found. The specific gravity is 2.65. It is harder than most minerals, being 7 on the Moh scale. Quartz is employed in ceramics, and as an abrasive. Quartz sandstones are used for grinding wheels. Due to its peculiar refractive powers quartz crystal is employed for the plates in polarization instruments, and for lenses. Pure fused quartz for tubes, crucibles, and furnace rods is sometimes sold under trade names, such as Vitreosol. Amethyst, topaz and some other gem stones are quartz. When fused quartz loses its crystalline structure it becomes a silica

glass with a specific gravity of 2.2, and a hardness of only 5 on the Moh scale. Most of the quartz used in industry for abrasive, filler, and other purposes is crushed and finely ground. Powdered quartz is also used in making ferro-silicon, and as a flux in melting metals. Pure quartz glass is transparent to ultraviolet light, and is sold under various trade names.

Quartzite. A rock composed of quartz grains cemented together by silica. It is firm and compact, and breaks with uneven, splintery, or conchoidal fractures. Most of the quartzites used are made up of angular grains of quartz, and are light in color. Quartzite is said to have been derived from sandstones by intense metamorphism. Quartzite is employed for making silica bricks, abrasives, siliceous linings for tube mills, as a structural stone, and as broken stone for roads. Quartzite is a widely distributed common rock.

Quebracho. The common name for the wood of the "Quebracho colorado," or red quebracho tree, *Aspidospera quebracho,* found only along the west bank of the Parana and Paraguay rivers in Argentina and Paraguay. It contains about 24 per cent of tannin, and is valued chiefly as a source of the quebracho extract of commerce. The trees are of average size. The wood is exceedingly hard, and has a brownish-red color often spotted and stained almost black. Quebracho is valued highly as a firewood in Argentina and Uruguay. It is also used for railway crossties and posts, but is too brittle for use in structural work. It is very durable, and takes a fine polish. The weight is 78 lb. per cu. foot.

Quebracho extract. The hard, resinous substance extracted from the wood of the quebracho tree by boiling. It is brownish-black in color, and extremely bitter. It is widely employed in tanning leather. The solid extract contains 62 per cent of soluble tannins, 21 per cent of water, and 10 per cent of insolubles. The tannin contained in

the extract has the empirical formula $C_{43}H_{50}O_{20}$. Quebracho extract is shipped in 60-kilogram sacks. Most of the extract is now made locally, and the industry is in the hands of a few large companies, one company controlling more than 2,500,000 acres of forest. Only a relatively small amount of logs are exported, but the extract shipped from Argentina and Paraguay reaches nearly 250,000 metric tons annually.

Queen's metal. A grade of Britannia metal containing a small amount of zinc. A typical composition is 88.5 per cent of tin, 7 of antimony, 3.5 of copper, and 1 of zinc. The use of zinc is of doubtful value, as it drosses the alloy, and is usually considered as a detriment.

Quenching oils. Oils employed for the quenching of steels in heat-treating. They remove the heat from the steel, but act more uniformly and not as suddenly as water. The oils used in quenching baths are usually compounded, although fish oils alone are sometimes employed. Fish oils, however, have offensive odors when heated. Vegetable oils alone are apt to oxidize and become gummy. Animal oils become rancid. Mineral oils compounded with fish, vegetable, or animal oils are sold under trade names, and vary considerably in their content. Oil quenching baths are usually kept at a temperature of not over 150 deg. F., by providing cooling pipes with running cold water. Tempering oils differ from quenching oils only in the fact that they are compounded to withstand temperatures up to about 525 deg. Fahrenheit.

Rack-a-rock. A high explosive consisting of cartridges of potassium chlorate, which are dipped just before use into a combustible oil. The latter may be nitrobenzene, or "dead oil." The dipping is prolonged until about a third of the weight of the chlorate has been taken up. It is then highly explosive and very sensitive to friction or heat. It is now only used as a war explosive when it it is desired to economize on nitrates. See also Prométhée.

Radiator compounds. Mixtures employed in the radiators of automotive or other internal combustion engines to lower the freezing point below the atmospheric temperature in order to prevent damage from the formation of ice. The requirements are that the compound must lower the freezing point considerably without lowering the boiling point, it must not corrode the metal nor deteriorate the rubber connections, it must be stable up to the boiling point, and it must be readily obtainable commercially. Calcium chloride was formerly the popular compound for automobile radiators, but it corroded the metals badly. Oils were also used, but the high boiling points permitted overheating of the engine, and the oils softened the rubber. The alcohols are now widely used, and 40,000,000 gal. of denatured ethyl alcohol is used annually in the United States for automobile radiators. Methanol, or wood alcohol, is even less corrosive, but it is not as easily obtainable. A 30-per cent solution of ethyl alcohol in water has a freezing point at about 0 deg. F., and a 50-per cent solution freezes at −24 deg. F. Glycerol is also used, a 40-per cent solution lowering the freezing point to about 0 deg. F., and a 50-per cent solution to −15 deg. F. It has the disadvantage of high viscosity, requiring forced circulation at low temperatures, and it is more costly than alcohol. The advantage is that it does not evaporate. Ethylene glycol lowers the freezing point to a greater extent than alcohol, but it softens rubber, and has a high first cost. A 25-per cent solution has a freezing point at −5 deg. F., without appreciably lowering the boiling point of the water.

Radioactive metals. Metallic elements which emit radiations that are capable of penetrating matter opaque to ordinary light. They give out light, and appear luminous, also having an effect on the photographic plate. The metal radium is the most radioactive of all the elements, and practically its only commercial substitute is mesothorium. It is employed for luminous paints for dials and pointers of instruments and for the hands of watches.

Other radioactive elements are: Uranium, thorium, ionium, actinium, and polonium. These bodies all have high atomic weight. The radiating power is atomic, and is unaffected in combinations. Radium and other radioactive metals are changing substances. Radium gives out three types of rays, while some of the other elements give out only one or two. The emanations are positively charged, and are projected at high velocity. These rays can be deflected by magnetic fields. An aluminum screen completely absorbs the α rays, while lead stops the β rays. After breaking up, the rays apparently go into the group of inert gases like argon and helium. By comparison of changing atomic weights it has been deduced that the metal lead is the ultimate product, and uranium the parent metal. Radium has apparently a period of transfer of several thousand years, while mesothorium disintegrates in little over 5 years. Polonium decays in a short time, losing half its weight in 140 days. See also Radium, Mesothorium, Uranium.

Radium. A peculiar radiactive element, symbol Ra, scattered in minute quantities throughout almost all classes of rocks. It was discovered in 1898 by Curie, and the first radium chloride separated from pitch blende in 1902. Radium is only commercially obtainable from the uranium ores, monazite sand, carnotite, autunite, uraninite, and thorite, and is believed to be formed by the disintegration of uranium or ionium. In Austria it is obtained from the residue of pitch blende after the extraction of the thorium oxides for the incandescent mantle industry. In the United States it is obtained from carnotite. From the first production in 1902 until 1926 little more than 300 grains of radium had been produced. It is the most expensive article of commerce. The ratio of radium to uranium in any uranium ore is always about 1 to 3,000,000. It is marketed in the form of bromides or sulphate in tubes. Radium has the property of radio activity greater than any other element. In a given interval of time a definite

proportion of the atoms break up with the expulsion of α, β, or γ rays. The most powerful ray is the γ. Radium is most widely known for its use in therapeutic medicine for the treatment of cancer and other diseases, but more than 90 per cent of the production is employed in luminous paints for hands and pointers of watches and instruments, and for luminous signs. See also Carnotite, Mesothorium, and Uraninite.

Rafaelite. Oxidized crude petroleum from seepings. It occurs in large beds on the eastern slopes of the Andes Mountains in Argentina, and is similar in appearance to asphalt. It takes its name from the town of San Rafael, Argentina, near which place large deposits appear. It has the same uses as asphalt, and is also capable of being distilled for oils and coal-tar products.

Ramie. Also known as China grass. A fiber used for cordage and for various kinds of coarse fabrics, and obtained from the plant *Boehmeria nivea* of temperate climates, and *B. tenacissima*, of tropical climates. The best ramie comes from China. The plants grow in tall slender stalks like hemp, and belong to the nettle family. The "bast" fibers underneath the bark are used, but are more difficult to separate than hemp fiber due to the insolubility of the adhesive gums. The fibers are very strong, and are fine, white, and are as silky as jute. They are not very flexible and are not in general suitable for ease of weaving, as they act like hairs, and have no natural affinity to cling together.

Rape oil. An edible, lubricating, and illuminating oil obtained from the seeds of several varieties of the turnip, *Brassica campestris.* It is widely used for mixing with lubricating and cutting oils, and for quenching oils. The seeds are very small, an ounce including as many as 40,000 seeds. The seeds contain 40 per cent of oil. The edible oil is cold-pressed, and refined with caustic soda. The burning and lubricating oils are refined with sulphuric acid. The iodine value is about 100, and the specific

gravity is about 0.915. The oil contains palmitic, oleic, linolic, and stearic acids, and a characteristic acid, $C_{22}H_{42}O_2$, called erucic acid. Rape oil is sometimes called colza oil, although this name more often refers to the oil from French seed. Rape oil is frequently "blown" for use as a lubricant. See Blown oil.

Raybestos. The trade name of an impregnated lining material employed for brakes and friction clutches. It is made of asbestos fibers woven together with fine brass wire and a binder, and then consolidated under pressure. The coefficient of friction of Raybestos is given as 0.45, and it is claimed to withstand high temperatures without charring. Another type of the material is made up compact under heavy pressure, and is intended especially for clutches. Raybestos is a product of the Raybestos Company, Bridgeport, Conn.

Rayon. The trade name for artificial silk. It consists of cellulose in solution squirted through fine holes into liquids containing chemicals which cause the cellulose to precipitate out in the form of fine threads. Various processes differ in the solvents and chemicals used. The chief source of the cellulose is waste cotton or cotton linters, as cotton is almost pure cellulose. Wood may be used after dissolving out the lignin. When the cellulose is dissolved in nitric acid nitro-cellulose is formed. This is the best known of the raw products for rayon making. A lesser concentration is used than when making nitro-cellulose for explosives. See Nitro-cellulose. When acetic acid is used the product is called cellulose acetate. These substances are dissolved in ether, ethyl or other alcohols, amyl acetate, or other organic solvents. Rayon was first known in 1855, but in 1910 less than 300,000 lb. of artificial silks were produced in the United States. In 1925 a total of 52,000,000 lb. were produced. Rayons manufactured by the different processes vary both chemically and physically. Cuproammonium and other solutions are employed for making the silks resistant and partly water-

proof. Rayon is dyed in many colors. See Pyroxylin, Cellulose acetate.

Red casting brass. The name of a high-copper brass with good casting properties. It also cuts and finishes well. Its composition as designated by the General Motors Corporation is: 85 per cent copper, 5 per cent tin, 5 per cent lead, and 5 per cent zinc. It has an average ultimate strength of 27,000 lb. per sq. in., and elongation of 18 per cent in 2 inches. See also Valve copper.

Red cedar. A name which is applied at times to various species of woods, none of which are botanically true cedars, but are of the genus *Thuja*, *Cedrela*, or *Juniperus*, such as toon, arbor vitae, and pencil cedar. The name is also sometimes applied to the yellow cedars. See Yellow cedar. It is also used to designate Canadian juniper. See Cedar.

Red lead. A common lead pigment. It is lead tetroxide, Pb_3O_4, forming a bright-red or orange-red powder of specific gravity 9.096, and insoluble in water. As a pigment it has great covering power and brilliancy, but must be applied immediately after mixing to avoid combination with the oil. It is used as a heavy protective paint for iron and steel. With linseed oil it is also used as a lute in pipe fitting. Orange mineral is a very pure form of red lead, and has an orange color. Red lead is made from lead metal by drossing and then heating in a furnace. It is ground for the market.

Refractories. Substances employed where resistance to very high temperature is required, such as for furnace linings and metal-melting pots. They are composed largely of alumina and silica, and are employed in the form of powder to be mixed into a paste and used like cement, or are in the form of bricks. They owe their properties largely to silica, magnesia and alumina. Clay is the oldest and most common of the refractories. The natural refractories consist of kaolin, chromite, bauxite, zirconia, magnesite, and they are marketed under many

trade names. Refractories may be "acid," such as silica, or "basic," such as magnesite or bauxite, for use in acid or basic process steel furnaces. Graphite and chromite are "neutral" refractories. Magnesia fuses at 3,929 deg. F. and chromite at 3,722 deg. F. The fusing point of the refractory, however, is usually dependent on the binder. The artificial refractories are silicon carbide, aluminum oxide, mullite. These are sold under a wide variety of trade names such as Carborundum, Alundum, Borolon, Refrax, Infrax and Aloxite. Good refractories should be of such a chemical composition that they do not fail below the melting point by great expansion or contraction, or by "spalling," that is, by cracking from unequal expansion. The artificial refractories should all withstand continuous temperatures in excess of 3,200 deg. F. See also Firebrick.

Redmanol. The trade name of a phenol resin molding compound and varnish, somewhat similar to Bakelite. It is a product of the Bakelite Corporation.

Redwood. The wood of the trees *Sequoia gigantea* and *Sequoia sempervirens*, native to the West Coast of the United States. The wood is light, soft, and spongy. It has a dull red color. The trees are of an immense size, and planks can be obtained 6 ft. in width. The weight of the wood is about 28 lb. per cu. ft. It has a tensile strength of from 7,000 to 11,000 lb. per sq. in. The wood is used in all kinds of common construction, and 510,639,000 board feet were produced in 1925. The name "redwood" is also applied to the dyewood, Brazil wood.

Refrax. The trade name of a silicon carbide refractory material manufactured by The Carborundum Company, Perth Amboy, N. J. It is composed entirely of silicon carbide held together by crystallization. It therefore has no bonding material of a lower melting point. It will withstand temperatures up to 2,240 deg. C., at which point it decomposes. The specific gravity is 3.18. The crushing strength of the brick is 12,500 lb. per sq. in.

It is used as a refractory lining for furnaces, but can be furnished only in simple shapes.

Resin. An important group of subtances obtained naturally as gums from trees, or manufactured synthetically, as the phenol resins and the casein resins. The common resin of the pine trees is chemically designated as rosin. Resins have a wide range of uses. The natural resins are soluble in alcohol and other organic solvents, and are used in varnishes. Oleo-resins are natural resins containing essential oils of the plant. The synthetic resins are used chiefly for molding mechanical and electrical parts. Some of the commercial resins are rosin, dammar, mastic, sandarac frankincense, lac, and anime. Gum-resins, not so soluble in alcohol, are gamboge, myrrh, rubber, gutta-percha and olibanum. Fossil resins are considered especially valuable, and owe their quality to the long formation through centuries. These are amber, kauri, and copal. See also Synthetic resins.

Resistance wire. The standard alloy for electrical resistance wire is nickel-chromium. For temperatures up to 2,000 deg. F. an alloy of about 80 per cent nickel and 20 per cent chromium is used. It has high resistance to oxidation. For less severe conditions an 85-nickel, 15-chromium alloy is used. The average alloy for resistance wire in general household heating devices contains about 62 per cent nickel, 12 chromium, and 26 per cent iron. It can be operated at temperatures up to 1,800 deg. F. For the cheaper type of heating appliances, or where high temperatures are not required, on alloy of about 26 per cent nickel, 8 chromium, and 66 per cent of iron is employed. Resistance wire alloys are marketed under various trade names such as Chromel, Rezistal, Nichrome, Calorite, Lucero, and Advance metal. These alloys may also contain other elements.

Rex steel. The trade name of a high-speed steel produced by the Crucible Steel Company of America. Grades A

and AA are standard high-speed steels, while grade AAA is a cobalt steel, and should be hardened at temperatures 75 to 100 deg. higher than for ordinary high-speed steel. The steels are used for cutting tools. Rex AAA steel should be forged at a temperature of not over 2,000 deg. F. See High-speed steel.

Rezistal. A chromium-nickel-silicon "steel" manufactured in several grades, all of which have high percentages of nickel and chromium. It is non-magnetic, and is resistant to heat, chemical action, and corrosion. Its specific gravity is 7.76. It casts very well, making sharp, clear-cut castings. It is rolled and forged at a yellow heat, about 2,000 deg. F. When annealed for several hours at 1,750 deg. F. and cooled in a furnace it can be machined readily. It can be forged and welded. In drawn wire form its tensile strength is as high as 150,000 lb. per sq. in. The average tensile strength of the rolled metal is 100,000 lb. per sq. in. with elongation of 20 to 35 per cent and Brinell hardness of 225 to 300. All grades of Rezistal are highly resistant to oxidation and scaling up to 2,200 deg. F. At 1,760 deg. F. the tensile strength is 21,000 lb. per sq. in. It is therefore valuable for use in baffle plates, spark plug electrodes, and other uses where heat resistance or acid resistance is required. It is highly resistant to sea water or mine waters. Rezistal is manufactured under U. S. patents 1,420,707 and 1,420,708 by the Crucible Steel Company of America.

Rhodium. A rare metal found in platinum ores. The chemical symbol is Rh. It is very hard, white, and brittle, and is one of the most infusible of the metals. The melting point is 3,542 deg. F. It is insoluble in most acids, and is not even dissolved by aqua regia. The specific gravity is 12.4. Rhodium is used to make the nibs of writing pens, and for the points of thermocouples. It forms a solid-solution alloy with platinum that is easily workable and does not tarnish nor oxidize at high temperatures. These alloys are used for thermocouples, and sometimes for chemi-

cal apparatus. Rhodium is sold by the troy ounce, one cu. in. weighing 6.56 troy ounces.

Rhodochrosite. An ore of manganese. It is found in small quantities in Connecticut, New Jersey, Colorado, and in the silver mines of Hungary and Saxony. It is a manganese protocarbonate, $MnCO_3$, with usually some iron replacing part of the manganese. It is usually a massive cleavable structure, sometimes granular. Its hardness is 3.5 to 4.5, and specific gravity 3.45 to 3.6. The color is rose-red to dark brown, with a vitreous luster.

Rhodolite. One of the varieties of common garnet used as an abrasive coating for paper and cloth. It is crystalline, and has a hardness of 6.5 to 7.5. It is in reality not a separate mineral, but is a mixture of two parts of pyrope and one of almandite. It is found in various parts of the eastern United States. It is pale rose-red or purple in color. See Abrasive garnet.

Rich low brass. An alloy of 85 per cent of copper and 15 per cent of zinc. It is very ductile, and has a reddish color. It is used for architectural work and hardware. It is one of the standard mixtures of the brass mills.

Rock crystal. A clear, colorless variety of quartz, commonly occurring in distinct crystals. Its chief use is for the manufacture of quartz optical glass. It is produced in many parts of the United States, but is also imported from Brazil. It is also cut into gem stones. See Quartz.

Roman cement. A "natural cement" made by calcining, or burning, various sandy limestones and grinding the product. The limestones used usually contain 60 to 70 per cent of calcium carbonate, 14 to 20 per cent of silica, and 5 to 10 per cent of alumina. Calcination is done at a moderately red heat, and the porous clinker is crushed and finely ground. Roman cement is cheaper and will set much more quickly than portland cement, but is softer and inferior in strength.

Roscoelite. One of the most important ores of vanadium produced in the United States. It is a muscovite mica in which a part of the aluminum has been replaced by vanadium. It occurs in mica-like scales varying in color from green to brown. It has a specific gravity of 2.9. The ore mined in Colorado contains only about 1.5 per cent of vanadic oxide.

Rosein. The trade name of a light-weight, white metal used chiefly for making jewelry and ornamental articles. It contains 40 per cent of nickel, 30 of aluminum, 20 of tin, and 10 of silver. It can be worked easily, and takes a good polish.

Rosewood. The wood of the jacaranda tree, *Dalbergia nigra*, used for fine cabinet work, pianos, and expensive furniture. It should not be confused with the wood of the tree *Physocalymma floridum*, which also comes from Brazil, and is there called "pao rosa" or rose wood. The color of rosewood is dark-brown, and it takes a beautiful polish. It has a characteristic fragrance. It is very hard, and has a coarse, even grain. The weight is 54 lb. per cu. foot.

Rosin. The common resin of several varieties of the pine tree, found widely distributed in North America and Europe. It is obtained by cutting a longitudinal slice in the bark and wood of the tree and allowing the exudation to drip into containers. The liquid resin is then distilled to remove the turpentine, and the residue forms the rosin of commerce. It is a reddish-brown translucent solid, inflammable, and easily fusible. It consists chiefly of abietic acid, of the empirical formula $C_{19}H_{29}COOH$. The specific gravity is 1.08, and the melting point is 100 to 140 deg. C. Rosin is soluble in alcohol, turpentine, and in alkalies. It is used in varnishes, paint dryers, soluble oils, belt dressings, and as a filler for other resins. It is sometimes also used in belt dressings. Rosin is generally graded commercially by letters from B to W, the grading being according to color. The darkest grade is B, and the lightest

is W. Extra grades are A, nearly black, and WW, water white. The dark grades are considered inferior, and are used for making rosin oil, and for linoleum manufacture. Rosin is usually marketed in wooden barrels.

Rosin oil. An oil produced by the dry distillation of rosin. The industry has been largely confined to Germany, France, and Scotland. The distillation is done in large retorts at a temperature of from 200 to 360 deg. C. There are two qualities of the oil, a light spirit, pinolin, which forms from 1 to 5 per cent of the rosin, and a bluish, heavy oil, which forms from 80 to 84 per cent. About 5 per cent of a coke-like residue is left, and from 10 to 15 per cent consists of gas and water. Crude rosin oil has a specific gravity of 0.986 to 0.995. It contains abietic acid, and has an acid value of about 28. It is purified by neutralization, and by the injection of air. When refined it is a yellow liquid, and may be used in adulterating turpentine. The heavier distillate is treated with lime and used as a lubricating oil, or for mixing with lubricating oils. The lighter distillate, known as oil of amber, is used in pharmacy.

Rottonstone. A soft, friable earthy stone of light-gray to olive color, used as an abrasive for metal and wood finishing. It resembles Missouri tripoli, and is derived from the weathering and decay of a siliceous-argillaceous limestone. Its chemical composition varies, but it contains generally from 80 to 85 per cent of alumina, 4 to 15 per cent of silica, 5 to 10 of carbon, and 5 to 10 per cent of iron oxides. Rottonstone is largely imported from England, but a variety is found in Pennsylvania. It is finely ground, and marketed either as a powder or in molded bricks. The latter form is used by wetting it with oil and holding it intermittently against the rag wheel used for polishing the work. A fine, 250-mesh powder is employed as a filler in phonograph records and molding compounds.

Rubber. A gum resin exudation of several species of trees of the genus *Hevea*, growing in all tropical countries,

but now cultivated extensively on plantations in the East Indies. The milk-like juice is dried over a fire into a dark, solid mass for shipment. Rubber has the remarkable property of being vulcanized by the addition of sulphur, making it harder and more elastic. The ordinary soft "rubber" used in industry contains from 3 to 5 per cent of sulphur, and usually some other substances. Litharge, lime, and magnesia are used to stiffen the rubber and speed up the vulcanization. "Red rubber" is colored with antimony red. When 30 per cent of sulphur is added and it is heated, rubber forms "hard rubber," or ebonite. For the rubber used in making automobile tires large percentages of carbon black and zinc oxide are used to reinforce it and give road wearing qualities. The consumption of rubber in the United States in 1927 was 370,636 tons, or 64 per cent of the total world consumption. More than 50 per cent of this was reclaimed rubber. About 87 per cent of the rubber consumption goes into automobile tires, although there are hundreds of other applications of rubber. Rubber contains isoprene, $(C_5H_8)_x$, and a synthetic rubber has been made from turpentine, petroleum oils, and from amyl alcohol, but is too expensive to compete against the natural product. See also Guayule, Balata, Gutta percha, Pontianak.

Rubidium. A rare metallic element, symbol Rb, belonging to the group of alkali metals, to which potassium belongs. The chief occurrence of rubidium is in the mineral lepidolite, although it is found in other minerals, and in tea, coffee, tobacco, and certain other plants. It is a silvery-white metal, with a specific gravity of 1.52, and a melting point of 39 deg. C. It takes fire easily in the air, and like potassium it decomposes water. It can be obtained by electrolysis, but has few industrial applications as yet due to its rarity and instability. Its chief use is for coating photoelectric cells for telephotographic and television instruments.

Ruby. A transparent variety of the mineral corundum, having a beautiful red hue. It ranks with the best grades

of precious stones as a gemstone, but is also used industrially for making pivot bearings in watches and fine instruments. The specific gravity is 4.03, and the hardness is 9, being nearly equal in hardness to the diamond. The color is due to chromic oxide. Most of the best rubies come from Upper Burma. Darker stones come from Siam. The carmine-red, or "pigeon's blood" stones are the most highly prized, and in large sizes are of more value than diamonds. For bearing uses synthetic rubies are largely substituted for the natural stones.

Ruthenium. A rare metallic element, symbol Ru, discovered by Claus in 1864. It is a hard, white metal, having a specific gravity of 12.1, and a melting point of about 4,440 deg. F. The Brinell hardness of the annealed metal is 220. It can be obtained in the metallic state by heating the oxide, RuO_2, obtained from the residue of platinum ores, in hydrogen. It is insoluble in most acids, and is not dissolved by aqua regia. Ruthenium is used as a hardener in platinum alloys, and has a powerful hardening effect on this metal. Ruthenium is sold by the troy ounce, a cu. in. of the metal weighing 6.38 troy ounces.

Rutile. The most common ore of the metal titanium. It is a titanium dioxide, TiO_2, containing theoretically 60 per cent of titanium. Its usual occurrence is crystalline or compact massive, with a specific gravity of 4.18 to 4.25, and a hardness of 6 to 6.5. The color is red to black. Rutile is found in granite, gneiss, limestone, or dolomite. It is obtained commercially from the sea beaches at northern Florida, and Espirito Santo, Brazil.

Sabeco metal. The trade name of a copper-tin-lead alloy used for machine bearings. It contains a high percentage of lead and belongs to the class of modified babbitt metals. See Babbitt. It is a product of the Fredericksen Company, Saginaw, Mich. It is furnished in ingots, solid or cored bars, or castings.

Sal ammoniac. The common name for ammonium chloride, NH_4Cl, which has a wide variety of industrial uses. See Ammonium chloride.

Salmon oil. This oil is obtained as a by-product in the salmon-canning industry, and is employed as a drying oil for finishes. There are different classes of the oil, depending upon the type of salmon. The oil contains palmitic and other acids. The specific gravity is about 1.260. It has a high iodine value, 168, but it does not form an elastic skin on drying, and is therefore inferior for varnishes.

Salt. The common name for sodium chloride, known in mineralogy as halite. It is widely used industrially for preservative and curative purposes, salt brine quenching baths, freezing mixtures, manufacture of soda ash, and for the extraction of gold by the chlorination process. Salt has the composition NaCl, containing theoretically 60.6 per cent of chlorine, and 39.4 per cent of sodium. It usually contains impurities such as calcium sulphate, and calcium and magnesium chlorides. It occurs in crystalline granular masses with cubical cleavage, known as rock salt. It is readily soluble in water, and occurs to some extent in all waters. It is also obtained by evaporation from salt lake or sea waters. The hardness is 2.5, and the specific gravity is 2.1 to 2.6. The melting point is 1,472 deg. F. It may be white or colorless, and when impure has shades of yellow, red, or blue. It has a characteristie salty taste. In making brines 100 parts of water at ordinary temperature will dissolve about 36 parts of salt. In the United States salt is produced on a commercial scale in 15 states, with an output of more than 7,000,000 tons annually. Commercial salt is marketed in many grades depending chiefly on the size of the grain. The salts sold under various trade names usually contain magnesium carbonate to make them free running.

Saltpeter. Also called niter. A common name for potassium nitrate, used chiefly in making gunpowder. The

name comes from the Latin, meaning rock salt. Chilean saltpeter is sodium nitrate. See Potassium nitrate.

Samson steel. The trade name of a chromium-nickel steel produced by the Carpenter Steel Company, Reading, Pa. It contains 1.25 per cent of nickel, 0.60 of chromium, and any desired percentage of carbon. It is furnished as forging billets, bars, cold-drawn rods, wire, or strip. The hot-drawn steel as marketed heat-treated, has a tensile strength up to 115,000 lb. per sq. in., an elongation of 18 per cent, and a reduction of area of 50 per cent. A cold-drawn grade has a tensile strength of 115,000 lb. per sq. in., and an elongation of 16 per cent. These steels can be heat-treated to give varying properties, according to the carbon content, up to a tensile strength of 240,000 lb. per sq. inch.

Sand. An accumulation of grains of mineral matter derived from the disintegration of rocks. It is distinguished from gravel only by the size of the grains or particles, but is distinct from clays which contain organic materials. Sands that have been sorted out and separated from the organic material by the action of currents of water or by winds across arid lands are generally quite uniform in the size of grains. Usually commercial sand is obtained from river beds, or from sand dunes originally formed by the action of winds. Much of the earth's surface is sandy, and these sands are usually quartz and other siliceous material. The most useful commercial sands are composed chiefly of silica, often above 98 per cent. Other materials in sand are feldspar, garnet, zircon, and tourmaline. Silica sands for making glass must be free from iron. Sand is used for making mortar and concrete, and very extensively for polishing purposes and for sand-blasting castings. Sands containing a little clay are used for making molds in foundries. Clear sands are employed for filtering water. Sand is sold by the cubic yard or ton, but is always shipped by weight. The weight varies from 2,600 to 3,100 lb. per

cu. yd., depending on the composition and size of grain. See Sandpaper, Abrasive sand, Sandblast sand.

Sandarac. Known also as white gum, or Australian pine-gum. A white, brittle resin obtained as a natural exudation from the coniferous tree *Callitris quadrivalvis*. It is used chiefly as a varnish gum, and contains resin acids and essential oil. It is soluble in alcohol and in turpentine. It is often adulterated with dammar. Ground sandarac, under the name of "pounce," is used for rubbing on tracing cloth to keep the ink from spreading and sinking in. In 1926 a total of 190,000 lb. of sandarac was imported into the United States.

Sand-blast sand. Any sand employed in a blast of air for cleaning castings, removal of paint, cleaning of metal articles, or for giving a dull, rough finish to glass or metal goods. It is also used for renovating the walls of stone or brick buildings. Sand-blast sand is not closely graded, and the grades vary with different producers. The United States Bureau of Mines gives the following as the usual range: No. 1 sand should pass through a 20-mesh and be retained on a 48-mesh screen; No. 2 should pass through a 10-mesh and be retained on a 28-mesh screen; No. 3 through a 6-mesh and be retained on a 14-mesh; No. 4 through a 4-mesh and be retained on an 8-mesh screen. Sharp grains cut faster, but rounded grains produce smoother surfaces. The sand is usually employed over and over, screening out the dust. In some cases the dust and fine used sand is mixed with fine clay and blasted wet. This is known as "mud blasting," and produces the dull finish on hardened steel tools.

Sandpaper. A heavy paper coated with sand grains on one side, and used as an abrasive, especially for the finishing of wood. For this purpose ordinary sand has been largely replaced by crushed garnet and artificial aluminum oxide, but the papers are still commonly referred to as sandpaper.

The grains of natural sand do not have the sharp cutting edges of grains broken down from larger fragments, and are therefore not as desirable as abrasives for woodworking. Some sandpaper is made from crushed quartz grains. For this purpose the quartz grains are prepared in grades from the 20-mesh, known as No. 3½, through No. 3, 2½, 2, 1½, 0, 00, and 000. All of the No. 000 grains pass a 150-mesh sieve, with 25 per cent retained on a 200-mesh sieve, and 80 per cent on a 325-mesh sieve. Good sandpaper quartz will contain at least 98.9 per cent of silica. The paper used is heavy, tough, and flexible, usually 70- or 80-lb. paper, and the grains are bonded with a strong glue.

Sandstone. A consolidated sand rock, consisting of sand grains united with a natural cementing material. The size of the particles and the strength of the cement vary greatly in different natural sandstones. The most common sand in sandstone is quartz, with considerable feldspar, lime, mica, and clayey matter. The cementing material is often fine chalcedony. Silica sandstones are hard and durable, but difficult to work. Calcareous sandstone, in which the grains are cemented by calcium carbonate, is called freestone, and is easily worked, but it disintegrates by weathering. The colors of sandstones are due to impurities, pure silicious and calcareous stones being white or cream colored. The yellow to red colors usually come from iron oxides, black from manganese dioxide, and green from glauconite. Various sandstones have local or trade names. Sandstones are employed for grindstones, and for building stones. See Grindstones.

Sapphire. A transparent variety of the mineral corundum. When it has the beautiful blue hue for which it is noted, it ranks with the diamond, ruby, and emerald among the precious gemstones. The off-color stones are cut for pointers and wearing points of phonographs and instruments. The specific gravity of sapphire is 4.03, and the hardness is 9 on the Moh scale. The blue color is due

to titanic oxide, and is rarely uniform in tint throughout the stone. The best sapphires come from Ceylon and India.

Sardine oil. A pale-yellow oil prepared from the refuse obtained in the sardine canning industry on the French and Spanish coasts. Japanese sardine oil is obtained on a larger scale by chopping up the fish and steaming. The oil is used as a drying oil for paints and varnishes and as an adulterant of linseed oil. The specific gravity is 0.927 to 0.933, and iodine value about 185. It contains a high percentage of palmitic acid.

Satin. A full-silk, heavy fabric with a close twill, or "satin," weave. In the satin weave the fine silk warp threads appear on the surface and the weft threads are covered up by the peculiar twill. Common satin is of 8-leaf twill, the weft intersecting and binding down the warp at every eighth pick, but sixteen and twenty twills are also made. In the best satins a fine quality of silk is used. The gloss is partly due to hot rolling. Cheaper varieties of imitation satin are made with a cotton weft. "Sateen" is made from mercerized cotton. Satins are dyed to many colors, and are sold under many trade names. In industry they are used chiefly for linings and trimmings.

Satinee. The wood of the tree *Ferolia guianensis*, of the natural order *Rosaceae*, native to tropical South America, particularly to the Guianas. The color of the wood is reddish-brown. It has a fine grain, is fairly hard, and takes a lustrous polish. The weight is 54 lb. per cu. ft. It is used for fine cabinet work.

Satin walnut. An English name for the wood of the American red gum tree, *Liquidambar styraciflua*, of the Southern States. See Gum.

Scandium. A metallic element, symbol Sc, which is found in wolframite, but has as yet no commercial use, because of its extreme rarity and difficulty of extraction.

Scheelite. An ore of the metal tungsten, occurring usually with quartz in crystalline rocks associated with wolframite, fluorite, cassiterite, and some other minerals. It is found in various parts of the United States, and in Europe, and Australia. Scheelite is a calcium tungstate, $CaWO_4$, usually containing some molybdenum to replace a part of the tungsten. It occurs massive granular, or in crystals, with a specific gravity of 6.05, and a hardness of 4.5 to 5. Its color is white, yellow, brown, or green, with a vitreous luster.

Schweitzer's reagent. A solution of copper hydroxide in ammonium hydroxide. It used as a solvent for nitrocellulose, and is also employed as a bath for dipping cloth or paper for waterproofing. After dipping, the material is put through hot rollers. The process of dipping and pressing glues together the fibers and makes it somewhat waterproof.

Scleron. The trade name of a light-weight alloy containing a high percentage of aluminum, with some copper, nickel, zinc, manganese, silicon, and lithium. The lithium is claimed to form a compound, Li_3Si, with the silicon. The alloy is strong and highly elastic. It is a product of the Metallbank u. Metallurgischen Gesellschaft, Frankfort A. M., Germany.

Scott's cement. The trade name of a lime plaster made by grinding together lime with 5 per cent of gypsum plaster. It is white in color, sets rapidly, and hardens quickly. It is not suitable for outside work or parts exposed to sea water as it is soluble.

Scouring abrasive. Natural sand grains or pulverized quartz employed in scouring compounds and soaps, buffing compounds, and metal polishes. The specifications of the Federal Specifications Board require that the abrasive grains used in grit cake soap and scouring compounds shall all pass a No. 100 screen, that the grains for scouring com-

pounds for marble floors must all pass a No. 100, and 95 per cent pass a No. 200 screen. For ceramic floors 90 per cent must pass a No. 80, and 95 per cent must pass a No. 60 screen. Very fine air-floated quartz is employed in metal polishes, and all grains pass through a 325-mesh screen.

Seal oil. An oil obtained by steam extraction from the blubber of the oil seal, *Phoca vitulina*. The industry centers largely around South Georgia in connection with the whale oil industry. Seal oil has a saponification value as high as 195, and an iodine value up to 150. It contains palmitic and other acids. It is used in lubricating and in cutting oils.

Selenium. An elementary metal, symbol Se, found native in cavities in Vesuvian lavas, and in combination with sulphur, and in copper and iron pyrites. It is prepared from the deposit in the making of sulphuric acid. Like sulphur it exists in various forms, having six allotropic forms. Amorphous selenium is a finely divided brick-red powder with a specific gravity of 4.26. Semi-colloidal red amorphous selenium is a blood-red solution. Vitreous selenium forms a brownish-black, brittle, glassy mass with a specific gravity of 4.28. Red and gray crystalline forms are also possible. Metallic selenium is made by fusing the vitreous variety and cooling slowly. The specific gravity is 4.82, and the melting point about 215 deg. C. The resistance of selenium is increased when heated, and diminished on exposure to light, the change of electric conductivity being instantaneous, even the light of small lamps having a marked effect. It is used for light-measuring instruments, and for the "photophone." It is also used as an accelerator in the vulcanizing of rubber. Selenium is odorless and tasteless, but the vapor has a putrid odor. It boils at 690 deg. C., and burns with a purple flame. The production of selenium in the United States in 1926 was about 250,000 pounds.

Semi-plastic bronze. A leaded bronze alloy used for the casting of light bearings. It is employed for machine bearings subject only to low speeds and light pressures. A typical composition is 78 per cent of copper, 16 of lead, and 6 per cent of tin. The ultimate strength of this alloy is 20,000 lb. per sq. in., and the elongation in 2 in. is 10 per cent.

Semi-steel. A cast iron made by adding steel scrap to the charge in the cupola. Low-carbon steel is used in the form of plates, bar ends, and rail croppings. The amount of steel varies from 15 to 40 per cent, the lower quantities for light work and the higher for heavy castings. The tensile strength is as high as 40,000 lb. per sq. in. When annealed at a temperature of about 800 deg. F. semi-steel castings become soft, with considerable ductility, but lose from 25 to 35 per cent of the tensile strength. Semi-steel has at times had a bad reputation because of the practice of employing miscellaneous scrap or junk steel, giving an irregular and unreliable product. Semi-steel made by the addition of steel of known chemical content such as rail croppings, however, is a superior product, and is valued for rolls and large machine frame castings. A semi-steel containing 25 per cent of steel scrap gave a tensile strength above 30,000 lb. per sq. in. The weight is 0.270 lb. per cu. inch.

Seventeen S. Usually written 17S. The trade name of a wrought aluminum alloy having high strength and suitable for use for mechanical parts where lightness and strength are required. It is a product of the Aluminum Company of America, and is marketed in the form of sheet, rod, wire, and rolled or extruded shapes. When heat-treated and aged it has a tensile strength of 60,000 lb. per sq. in., an elongation of 20 per cent in 2 in., and a Brinell hardness of 95. The composition is from 3.5 to 4 per cent of copper, 0.2 to 0.5 per cent of magnesium, 0.4 to 0.5 per cent of manganese, and the balance aluminum. Modified

grades are made without the manganese. The melting range of the alloys is from 540 to 650 deg. C. The heat-treatment is accomplished by heating to a temperature of about 950 deg. F., and quenching.

Shale. A rock formed by mud or clay consolidated under pressure. It is fine-grained and has a laminated structure, and is largely composed of silica and alumina with various impurities, often colored by oxides of iron. Unlike sandstones, shales have little porosity, but some shales contain mineral oils and form a vast future supply of fuel oils. Shale is used with limestone in making portland cement. Slate is another form of shale.

Shale oil. An oil obtained from the oil-bearing shales found in many parts of the world. They are mined for oil recovery in France, Great Britain, Austria, United States, Serbia, and Australia, and occur in great quantities in Argentina and in many other countries. Shale oil in the crude state is dark green to brown in color, and has a specific gravity of 0.850 to 0.950. The oil is obtained by distillation in retorts, the yield varying from almost nothing up to 100 gal. per ton. Scotch shale gives an average yield of 24.5 gal. of crude oil and 35.7 lb. of ammonium sulphate per short ton. The shale occurs in strata, and is mined like coal. It is a gray to black mineral with a laminated fracture. The oil contains more unsaturated constituents than petroleum. The products obtained by refining the crude oil include: Gasoline 10 per cent, illuminating and fuel oils 49 per cent, lubricating oils 7 per cent, and paraffin wax 9 per cent. It is estimated that there are 2,000 sq. mi. of oil shale lands in the state of Colorado alone with a total of 38 billion tons of oil-bearing shale available.

Shear steel. The steel produced from blister steel by cutting and piling together, heating to a high temperature in a "shingling" furnace to weld together, and then rolling or hammering into bars. When this "single shear" steel

is cut again into short lengths, piled, welded, and redrawn into commercial bars, it is called "double-shear steel." Before the advent of crucible steel shear steel was the only commercial form of steel.

Sheepskin. The skin of numerous varieties of sheep, employed for fine leather for many uses. The best sheepskins come from the varieties of sheep yielding the poorest wool. When the hair is short, coarse, and sparce the nourishment goes into the skin. The marino types having fine wool have the worst pelts, while wild sheep and the "low-wool," "cross-breds," and others of China and India have close-fibered firm pelts comparable with goatskins. The lambs grown in the mountains of Wales, Scotland, and the Western United States also furnish good skins. Sheepskins are tanned with alum, chrome, or sumac. The large and heavy skins from Argentina and Australia are often split, and the grain side tanned in sumac for bookbinding and other goods, while the flesh side is tanned in oil or formaldehyde and marketed as "chamois." The fine-grained sheepskins from Egypt are lined and specially treated to form "mocha" leather. The United States consumes about 50,000,000 sheepskins annually.

Shellac. A product of the insect *Tachardia lacca.* See Lac-dye. Crude stick-lac is crushed and washed to remove dirt and woody fiber, and the lac-dye extracted. The resulting product, seed-lac, is melted and squeezed through cotton cloth, yielding shellac. Commercial shellac comes from India, and when pure varies from a pale-orange to a lemon-yellow color. White shellac is made by bleaching with alkalies. Shellac is about 91 per cent resinous, and is often adulterated with common rosin. It is easily soluble in alcohol and in alkalies. Garnet lac is the material with the lac-dye left in. Shellac is widely used as a varnish, for phonograph records, and as an insulating coating. It is also valued for coating drawings as they can be washed from the oil and dirt accumulated in usage. The shellac

can be removed with alcohol without erasing the pencil lines, for altering the drawing. It is also used as a stiffening material, and as a binder for abrasive wheels. About 10,000 tons, or about 60 per cent of the world's production of shellac, is consumed annually in the United States. Shellac is graded according to color, and freedom from dirt. It usually contains up to 3 per cent of common rosin, but is often adulterated with more.

Shoddy. The shredded and recovered wool of old cloth. It is either manufactured directly into new fabric, or is mixed with new fibers before manufacturing. The word has an approbrious signification in the United States, due to its reputed use in poor-quality uniforms during the war, and the name is therefore never used to designate the many fabrics made from shoddy wool. Shoddy wool is used for adulterating wool. "Extract wool" is shoddy wool that is recovered by dissolving out the cotton fibers of the old cloth with sulphuric acid.

Sideraphite. The trade name of an acid-resisting alloy containing 62 per cent of iron, 23 of nickel, 5 of copper, 5 of aluminum, and 4 of tungsten.

Siderite. An ore of iron which has commercial importance in Great Britain, where it is the chief source of the metal. It is found in Staffordshire, Yorkshire, and Wales, and in the United States in Pennsylvania and Ohio. It is an iron carbonate, $FeCO_3$, containing theoretically 48.2 per cent of iron. It usually occurs granular, or compact and earthy. Its specific gravity is 4.5 to 5, and the hardness is 3.5 to 4. The color is light to dark-brown, with a vitreous luster. It often is impure, with a mixture of clay materials or forming stratified bodies with coal formations. Impure forms mixed with clay and sands are called "clay ironstones," "black band," and "niggerhead" ores. The ironstone and black band ores are the important ores of England and Scotland.

Sienna. A kind of brownish-yellow ochre found near Sienna, Italy, and employed as a pigment for paints. The material in its natural state is called raw sienna. Burnt sienna is the material that has been burnt to a chestnut color. See Ochre.

Sifbronze. A special alloy used for welding cast iron or malleable iron. It is a product of the Suffolk Iron Foundry, Ltd., Stowmarket, England. The alloy consists of 60 to 70 per cent of copper, 20 to 35 per cent of zinc, and some tin and ferromanganese. It has a tensile strength of 32 tons per sq. in. The melting point is about 1,300 deg. F. The material is marketed in the form of rods. Borax is used as the welding flux. The welded joints retain the full tensile strength of the alloy and are readily machined.

Silcrome. The trade name of a heat-resistant alloy steel used for automobile engine valves. It contains high percentages of silicon and chromium, and has a medium carbon content. It is claimed to withstand temperatures up to 1,700 deg. F. for long periods without scaling. For valve use it does not burn, pit, or warp. It machines readily. Silcrome is a product of the Ludlum Steel Company.

Silesia. The trade name of a German high explosive used for blasting purposes. It is a form of cheddite, and consists of potassium chlorate incorporated with oxidized rosin. It may also contain a proportion of sodium chlorate to make it less sensitive to detonation. Ordinary silesia contains 80 per cent of potassium chlorate and 20 per cent of rosin. The excess of chlorate produces gases with about 14 per cent of free oxygen when exploded.

Silex. The trade name of a finely ground white tripoli employed as an inert filler in paints. Missouri tripoli containing iron oxide is not suitable for this purpose. Much Illinois fine-grained tripoli is used for paint filler. Pulverized flint from Belgium, used for tube-mill lining,

is also known as Silex. In both cases the product is nearly pure silica.

Silexon. The trade name of a silicon carbide made in the electric furnace, and used as an abrasive. It is a product of the Bridgeport Safety Emery Wheel Company, Bridgeport, Conn. See Silicon carbide.

Silica. A mineral of the composition SiO_2, which is the most common of all materials, and in the combined and uncombined states is estimated to form 60 per cent of the earth's crust. Many sands, clays, and rocks are largely composed of silica. Silica is the weakest of the inorganic acids, but it forms definite salts with bases. When pure, silica is colorless to white. It is either crystallized or amorphous. It is insoluble in water when anhydrous, and is also insoluble in all acids except hydrochloric. Crystallized silica in the form of quartz has a hardness of 7 on the Moh scale, and a specific gravity of 2.65. It melts at a temperature of 3,090 deg. F. Silica has many industrial uses, among which are the manufacture of paints, glass, ceramics, and cements, and for abrasives and building stones.

Silicic acid. A reaction product of sodium silicate and hydrochloric acid. The empirical formula is given as H_5SiO_5. It is a jelly-like substance, which on drying absorbs water of crystallization, and leaves the sodium chloride of the reaction. Silicic acid, when dried and ground, has the physical appearance of quartz sand. It is mixed with wood pulp powder for molding purposes. Machinery bearings molded of 25 per cent wood pulp and 75 per cent of silicic acid are claimed to absorb a large amount of lubricating oil and to have excellent wearing qualities.

Silicon. One of the non-metallic elements, symbol Si. It is used in iron, steel, and in non-ferrous metals to give hardness and other characteristics. Its melting point is 2,615 deg. F., but it readily dissolves in molten metals. I

is never found free in nature, but combined with oxygen it forms silica, SiO_2, one of the most common substances in the earth. Silicon was discovered in 1823 by Berzelius, and can be obtained in three modifications. Amorphous silicon is a brown-colored powder with a specific gravity of 2.35. It is fusible and dissolves in molten metals. When heated in the air it burns to form silica. Graphitoidal silicon consists of black glistening spangles, and is not easily oxidized and not attacked by the common acids, but is soluble in alkalis. Crystalline silicon is obtained in dark, steel-gray globules or six-sided pyramids. It is less reactive than the amorphous form, but is attacked by boiling water. All of these forms are obtainable by chemical reduction. Silicon is an important constituent of commercial metals. Molding sands are largely silica, and silicon carbides are used as abrasives. Commercial silicon is sold in the graphitoidal flake form, or as ferro-silicon, and silicon-copper. Commercial refined silicon contains 97 per cent of pure silicon and less than 1 per cent of iron. It is used for adding silicon to aluminum alloys.

Silicon-aluminum alloys. Alloys of aluminum containing up to 15 per cent of silicon, used chiefly for casting purposes. The silicon makes a greater degree of fluidity in pouring, small shrinkage, and soundness in the casting. For making the alloys, a 50-50 silicon-aluminum "hardener" is used. This hardener melts at 1,050 deg. C. The silicon also increases the ultimate strength. The alloys are lighter than aluminum alone, or the aluminum-copper alloys. A 15-per cent silicon-aluminum alloy has a density of 2.631. The 7-per cent alloy may be cast around a steel liner and will not crack in cooling. With contents up to 10 per cent of silicon the alloys are ductile and easily worked, but the high silicon alloys are brittle and unworkable. In machining silicon-aluminum alloys the metal drags under the tool. Other elements are sometimes added as modifying agents. Silicon-aluminum alloys are marketed under various trade names such as Silumin.

Silicon bronze. A bronze containing silicon, which acts as a fluxing agent, and very little remains in the alloy. Silicon bronze possesses great strength and tenacity, and the small amount of silicon present acts as a hardener, and gives the alloy still greater resistance to corrosion. It is well adapted for telegraph and telephone wires, and is also used for trolley wires. The standard for wire has 98.55 per cent of copper, 1.40 of tin, and 0.05 per cent of silicon. It has a tensile strength when hard-drawn of about 92,000 lb. per sq. in. Silicon bronze may be sold under various trade names. See also Phono alloy.

Silicon carbide. A bluish-black crystalline artificial mineral of the composition SiC, having a hardness of 9.5 on the Moh scale, and used as an abrasive in the form of powder, paper, wheels and hones. It is also used as a refractory material, being bonded with clays or held together with its own crystals by a method of recrystallization. Silicon carbide is a product of the resistance-type electric furnace, made by fusing sand and coke with sawdust, using salt as a flux. The temperature used is just above 4,000 deg. F. It was discovered accidentally in 1891 by E. G. Acheson. The specific gravity is 3.12 to 3.20. As a refractory it will withstand temperatures up to about 4,200 deg. F., at which point it decomposes. Pure silicon carbide should contain 70 per cent of silicon and 30 of carbon, but the commercial grades contain less silicon and have small amounts of iron oxide. Unlike aluminum oxide, the crystals are large, and it is crushed to make the small grains required for abrasive purposes. It is harder than aluminum oxide, and is used for the hardest types of grinding wheels. Silicon carbides as abrasives and refractories are sold under a great variety of trade names such as Carborundum, Crystolon, Carbofrax, Carbora, Carborite, Crystolite, Electrolon.

Silicon-copper. An alloy of silicon and copper used for adding silicon to copper, brass, or bronze, and also employed as a deoxidizer of copper. Silicon alloys in almost any

proportion with copper, and is the best known hardener of copper. A 50-50 alloy of silicon and copper is hard and extremely brittle, and black in color. A 10-per cent silicon, 90-per cent copper alloy is as brittle as glass, and in this proportion silicon-copper is used for making the addition to molten copper to produce hard, sound copper castings of high strength. The resulting copper alloy is easy to run in the foundry and does not dross. Silicon-copper grades in 5, 15, and 20 per cent of silicon, are also marketed regularly, all of these being usually sold in slabs notched for breaking into smaller sections for adding to the melt in the furnace.

Silicon-manganese. An alloy employed for adding manganese to steel, and also as a deoxidizer and scavenger of steel. It usually contains from 65 to 70 per cent of manganese and 16 to 25 per cent of silicon. It is graded according to the amount of carbon contained in it, generally 1, 2, and 2.5 per cent. For making steels low in carbon and high in manganese silico-manganese is claimed to be more suitable than ferro-manganese. A reverse alloy, called manganese-silicon, contains 73 to 78 per cent of silicon, and 20 to 25 per cent of manganese, with a maximum of 1.5 per cent of iron, and a maximum of 0.25 per cent of carbon. It is used for adding manganese and silicon to metals without the addition of iron. Still another alloy is called ferro-manganese-silicon, and contains 20 to 25 per cent of manganese, about 50 per cent of silicon, and 25 to 30 per cent of iron, with only about 0.20 per cent of carbon. This alloy has a low melting point, which permits it to be taken readily into solution.

Silicon-spiegel. An alloy of silicon and manganese with iron, employed for making furnace additions of silicon and manganese to open-hearth steels. A typical analysis gives 20 to 25 per cent of manganese, 6 to 8 per cent of silicon, and 2 to 3 per cent of carbon. Both the silicon and manganese act as strong deoxidizing agents, making clean steel.

Silicon steel. All grades of steel contain some silicon, and most steels contain from 0.05 to 0.30 per cent. But from 3 to 5 per cent of silicon is sometimes added to increase the magnetic permeability, and larger amounts are added to obtain wear-resisting or acid-resisting properties. The silicon increases the hardness and makes the metal brittle, and also increases the corrosion-resistance. The lower grades can be rolled, however, and silicon-steel sheet is much used for electric transformer laminations. Silicon forms a chemical combination with the metal, forming an iron silicide, FeSi. As a casting metal steel or iron containing considerable amounts of silicon make sound castings without blow holes, as the silicon aids in the deoxidation of the molten metal. The maximum tensile strength is claimed to be at 4.5 per cent of silicon. The steels containing above 5 per cent of silicon cannot be rolled or forged. Irons containing from 12 to 17 per cent of silicon are used as an acid-resisting alloy. The highest corrosion-resistance is claimed to be at 14.5 per cent of silicon. The silicon-irons with more than 5 per cent of silicon are very brittle. They cannot be machined, but are cast and ground to form. Silicon steels and irons are marketed under various trade names, such as Duriron, Tantiron, Elianite, Corrosiron.

Silk. The fibrous material in which the silk worm, o larvae of the moth *Bombyx mori*, envelops itself befor passing into the crysalis state. Silk is closely allied t cellulose, and resembles wool in structure, but unlike woo it contains no sulphur. The natural silk is covered with wax or silk glue which is removed by scouring in manufac ture, leaving the glossy fibroin. The fiber is unwoun from the cocoon, and spun into threads. Each cocoon ha from 2,000 to 3,000 yards of thread. One pound of ra silk is obtained from 2½ lb. of cocoons. The world' production of silk is about 75,000,000 lb. annually, th chief silk producing countries being China, Japan, Indi Italy, and France. About 70 per cent comes from Japan

Japanese raw silk is shipped in bales of 100 kin. (132 lb.). The "conditioned weight" in shipping is the dry weight plus 11 per cent of moisture. In China the cultivation of the silkworm is claimed to date back to 2,640 B.C. Silk was first woven in Rome about 50 B.C. The eggs of the silkworm were smuggled into Europe in the year 552. Sericulture, or silkworm culture, is a highly developed industry. The larvae, which have voracious appetites, are fed on mulberry leaves for 24 days, after which they complete their cocoon in 3 or 4 days. In from 7 to 10 days these are heated to kill the crysalis to prevent bursting of the shell. The reeling is done by hand and by machine. Wild silk, or Tussah silk, is a coarser variety obtained from species of silk worms that do not feed on the mulberry. Artificial silk is now also made on a large scale. See Rayon.

Sil-O-Cel. The trade name of a heat-insulating material used for furnace linings and firebrick. It is composed essentially of kieselguhr, and is marketed in various grades. It is a product of the Celite Products Company, New York. Sil-O-Cel is the crushed "Celite" bonded with diatomaceous earth and burned. One grade will withstand temperatures up to 2,200 deg. F., and another is for temperatures up to 2,500 deg. F. The crushed material is also marketed for mixing with cement. See also Celite.

Silumin. A German light-weight alloy containing from 11 to 14 per cent of silicon and the balance aluminum. It is used as a casting alloy for automotive engine parts. It casts well, with little shrinkage. It is about 10 per cent lighter in weight than aluminum. Silumin machines very readily. See Aluminum-silicon alloys.

Silvel. The trade name of a German silver alloy containing 67.5 per cent of copper, 16 per cent of zinc, and 6.5 per cent of nickel. It is white in color, and has the general characteristics and used of the nickel silvers.

Silver. A white metal, very malleable and ductile, and classed with the precious metals. Its chemical symbol is

Ag. It occurs in the native state, and also combined with sulphur and chlorine. Copper, lead, and zinc ores frequently contain silver, and about 70 per cent of the world's production of silver is obtained as a by-product of the production of these metals. It is profitable to extract the silver from lead ores having only 3 oz. per ton. Silver is the whitest of all the metals, and takes a high polish, but easily tarnishes in the air because of the formation of a silver sulphide. It does not corrode. It has the highest electrical and heat conductivity. The specific gravity is 10.7, and the melting point is 1,762 deg. F. It is soluble in nitric acid, and in hot sulphuric acid. The tensile strength of cast silver is 41,000 lb. per sq. in. The metal is marketed on a troy-ounce value. Silver is used largely for coinage, ornaments, tableware, silver-plating, for alloying with gold, and in the form of its salts for photography and other uses. See Sterling silver.

Silver solder. A "high-melting-point" solder employed for soldering joints where more than ordinary strength is required. It is in reality a "brazing" metal, and the soldering is done with a blow torch. Silver solders are alloys of silver and copper in proportions arranged to obtain the desired melting point. Other metals are also added to reduce the melting point, or to give other properties. A typical silver solder, having a melting point of 1,305 deg. F. contains 32 per cent of silver, 23 of copper, 17 of zinc, and 18 of cadmium.

Simplex steel. The trade name of a chrome-nickel steel made by the Crucible Steel Company of America. Simplex forging steel contains 1¼ per cent of nickel and 0.60 per cent of chromium. It is claimed to be equal in physical properties to a 3½-per cent nickel steel, without having the tendency to laminate as does nickel steel. The tensile strength when heat-treated is 130,000 lb. per sq. in., elongation 17 per cent, and Brinell hardness 290. Simplex case hardening steel has less carbon. It has a tensile strength of 90,000 lb. per sq. in., and an elongation of 16 per cent. It i

especially adapted for gears, giving a hard wearing surface and great toughness.

Sisal hemp. The fibers obtained from the large leaves of the "century plant," *Agave rigida*, and employed for making rope, cordage, and sacking. About 80 per cent of all binder twine is made from sisal. The agave plant grows chiefly in Mexico, and most of the sisal hemp comes from Yucatan, where it is called henequen. The fiber is obtained by scraping off the fleshy parts of the leaf, washing, and drying. The fibers are not as long nor as strong as those of Manila hemp. Other varieties of agave plants also yield fibers, but are inferior for cordage purposes.

Slag. The molten material that floats on the surface of the iron in the blast furnace and remains as a residue after the iron is drawn off. Slag is formed from the earthy materials in the ore and from the flux. Slags are produced in the melting of other metals, but iron blast furnace slag is usually meant when the term is used commercially. Slag is used in cements and concrete, for roofing, and as a ballast for roads. Blast furnace slag is considered the lightest form of concrete aggregate available, and is superior to gravel. About 1,300 lb. of slag is produced for every long ton of metallic iron. It is also crushed and used for making Puzzuolani and other cements. Slag contains about 32 per cent of silica, 14 of alumina, 47 of lime, 2 of magnesia, and small amounts of other elements. It is crushed, screened, and graded for marketing. Crushed slag weighs 1,900 to 2,000 lb. per cu. yd. "Honeycomb slag" weighs only about 30 lb. per cu. ft. The finest grade of commercial slag is from $\frac{3}{16}$ in. to dust, while the "run-of-crusher slag" is from 4 in. to dust.

Slate. A shale possessing a straight cleavage. Most shales are of sedimentary origin, and their cleavage was the result of heavy or long continued pressure. In some cases slates have been formed by the consolidation of volcanic ashes. The slaty cleavage does not usually coin-

cide with the original stratification. Slate is of various colors, black, gray, green, and reddish. It is used for electric panels, blackboards, slate pencils, table tops, roofing shingles, floor tiles, treads, and flagstones. Slate is quarried in large blocks, and then slabbed and split with a chisel. Roofing slates vary in size from 12 by 6 in. to 24 by 14 in., and from ⅛ to ¾ in. in thickness. "Ribbon slate," with streaks of hard material, is inferior for all purposes. Lime impurities can be detected by the application of dilute hydrochloric acid to the edges and noting if rapid effervescence occurs. Iron is a detriment to slates for electric purposes.

Slate-lime. An intimate mixture of finely divided calcined slate and lime, either in the proportion of half and half, or about 60 per cent by weight of lime to 40 of calcined slate. It is employed for making porous concrete for insulating partition walls. The process consists in adding a mixture of slate-lime and powdered aluminum, zinc, or magnesium to the cement. The gas generated on the addition of water makes the cement porous.

Smalt. Also called royal blue, or Saxon blue. A very deep-blue powdered glass used as a pigment. It contains 65 to 71 per cent of silica, 16 to 21 per cent of potash, 6 to 7 per cent of cobalt oxide, and a little alumina. It is durable, but does not have good covering power. It is chiefly used in coloring blue glass or vitreous enamels.

Soap. A cleansing compound of grease and alkali depending for its action largely on a small proportion of free alkali. When caustic soda is added to fat, glycerin is separated out, leaving sodium oleate, $Na(C_{18}H_{33}O_2)$, which is soap. If an excess of alkali is used the soap will contain free alkali, and the greater the proportion of free alkali the coarser is the action of the soap. Auxiliary ingredients are used in soap to improve the color, for perfuming, as an astringent, or for abrasive or harsh cleansing purposes. Zinc oxide, benzoic acid, and other chemicals are also added

to facial soaps with the alleged idea of aiding complexion. Soaps are marketed in bars, cakes, liquid, chips, or paste. Excessive alkalinity in soaps dries and irritates the skin. Silicate of soda, used as a filler, also irritates the skin. Antiseptics may also be dangerous due to absorption through wounds. Soap is made by saponifying fats or oils with sodium hydroxide. Floating soaps are made light by blowing air into them while in the vats. Coconut oil is used in some soaps for producing a copious lather. Soaps are the basis of most commercial cleansing compounds, and are of wide utility.

Soapstone. A massive variety of talc having a fine granular structure. See Talc. It can be cut easily, and becomes very hard when heated due to loss of some of its combined water. It is employed for electric panels, gas jet tips, heating pads, stove linings, and for abrasive purposes. It is known in minerology as steatite.

S.O.B.V. cutting alloy. The trade name of an alloy used for cutting-tools in place of high-speed steels. It is claimed to cut harder metals, and at higher speeds than high-speed steel. Unlike the cobalt-base alloys, such as Stellite, the cutting properties of this iron-base alloy are not inherent in the alloy, but are produced by heat-treatment as with steels. But unlike cobalt-base alloys it can be forged, annealed and machined. The alloy contains high percentages of iron, chromium, cobalt, and tungsten, and also contains vanadium and molybdenum. It is hardened by heating to a temperature of 2,370 deg. F., and then cooling in an air blast, or in an oil bath. It is then tempered by reheating to 1,090 deg. F., and holding at this temperature for 20 to 40 min. S.O.B.V. cutting alloy is a product of Samuel Osborn & Company, Ltd., Sheffield, England.

Soda ash. The common name for commercial sodium carbonate, Na_2CO_3, which is the most important industrial alkali. It is less expensive than caustic soda, and is used

for cleansing, for softening water, in glass, in the wood pulp industry, for refining oils, in soaps, and it has many other applications. It is a grayish-white powder or lumpy substance, and comes in two grades, containing 48 and 58 per cent of alkali, Na_2O, respectively. The 58-per cent grade is marketed as "light" or "dense," the latter being twice as heavy per unit volume as the light. The dense variety is preferred where bulk is desired, as in glass. Soda ash is made from sodium bicarbonate, which in turn is made from common salt.

Soda lime. A mixture of hydrated lime and an alkali, used for freeing the air of carbon monoxide, and as a chemical purifying agent. It is also used in gas masks for chemical warfare. For the latter use it contains about 18 per cent of cement, 8 per cent of kieselguhr, and 1.5 per cent of sodium hydroxide. The cement is for the purpose of making fine granules.

Soda niter. A mineral found in large quantities in the arid regions of Chile, Argentina, and Bolivia. It is quarried, and used as a source of nitrogen compounds, chiefly for nitric acid, explosives, and fertilizers. The composition of soda niter is $NaNO_3$. It is usually of massive, granular crystalline structure. The hardness is 1.5 to 2, and the specific gravity is 2.29. It is colorless to white, but sometimes yellow, gray, or brown. It is readily soluble in water. In other desert regions it occurs in beds with common salt, borax, and gypsum.

Sodium. A metallic element, symbol Na. It occurs only in the form of its salts. The most important minera[l] containing sodium is the chloride, $NaCl_2$, which is commo[n] salt. It also occurs as a nitrate, Chile saltpeter, as a borat[e] in borax, and as a fluoride and a sulphate. When pur[e] sodium is silvery white, ductile, and melts at 204 deg. [F]. The specific gravity is 0.971. It can be obtained in metall[ic] form by the electrolysis of salt. When exposed to t[he] air it oxidizes rapidly, and must be kept in air-tight co[n-]

tainers. Sodium is widely employed in industry in its salts. It can be used as a deoxidizer in copper alloys when first alloyed with tin or other low melting point metal. An alloy of 95 per cent of tin and 5 per cent of sodium acts in the same way as phosphor tin.

Sodium aluminate. A white powder of the composition $Na_2Al_2O_4$, used as a water-softening agent with lime and soda in steam boilers. It has a melting point of 1,800 deg. C., and is soluble in water, but not in alcohol. It is made by the reaction of alumina with some source of sodium oxide such as caustic soda or soda ash, or by heating bauxite with sodium carbonate, and extracting with water.

Sodium cyanide. A salt of hydrocyanic acid of the composition NaCN, used for carbonizing steel for case-hardening, for electro-plating, and for the extraction of gold and silver from their ores. For carburizing steel it is preferred to potassium cyanide because of its lower cost and its higher content of available carbon. It contains 53 per cent of CN, as compared with 40 per cent in potassium cyanide. The nitrogen also aids in the carbonization. Sodium cyanide is very unstable, and on exposure to moist air liberates the highly poisonous hydrocyanic acid gas, HCN. It is valued for gold and silver extraction because it easily combines with the metals forming soluble double salts, $NaAu(CN)_2$. It is made by passing a stream of nitrogen gas over a hot mixture of sodium carbonate and carbon in the presence of iron as a catalyst. It is a white crystalline powder, soluble in water. It is usually packed in 100- and 200-lb. containers, made up in 1-oz. briquettes, 4-oz., egg, or fused and broken.

Sodium ferrocyanide. Also known as yellow prussiate of soda. It is a lemon-yellow crystalline solid of the composition $Na_4Fe(CN)_6{\cdot}10H_2O$, used for carbonizing steel for case-hardening. It is also employed in paints and printing inks, and for the purification of organic acids. It is soluble in water.

Sodium hydroxide. Known commonly as caustic soda, and also as sodium hydrate. A white, massive crystalline solid of the composition NaOH, used for scouring and cleaning baths, for etching aluminum, and in cutting and soluble oils. It has also a wide variety of other commercial uses. Sodium hydroxide is made by the causticization of soda ash, or by the electrolysis of salt. The specific gravity is 2.13, and melting point 318 deg. C. It is soluble in water, alcohol, and in glycerin. Sodium hydroxide is sold in both the liquid and a solid state on a basis of its Na_2O content.

Sodium nitrate. Also called soda niter, and Chile saltpeter. A mineral found in large quantities in the arid regions of Chile, Argentina, and Bolivia. It is used for making nitric and sulphuric acids, for explosives, as a flux in welding, and as a fertilizer. The composition is $NaNO_3$. It is usually of massive granular crystalline structure with a hardness of 1.5 to 2. It is colorless to white, but sometimes colored by impurities. It is readily soluble in water. In other parts of the world it occurs in beds with common salt, borax, and gypsum. Synthetic Chile saltpeter is made by nitrogen fixation, and is marketed granulated, in crystals, or in sticks. It is colorless, odorless, has a specific gravity of 2.267, and a melting point of 316 deg. C. It has a bitter saline taste. It has the same uses as the natural product.

Solder. An alloy of two or more metals used for joining other metals together by surface adhesion. A requirement is that it have a lower melting point than the metals being joined. The most common solder is called half-and-half, and is composed of equal parts of lead and tin. It melts at 370 deg. F., although the melting point of lead is 621 deg. F., and of tin 449 deg. F. Commercial half-and-half, however, usually contains larger proportions of lead and some antimony, because of the high cost of tin. Various melting points to suit the work are obtained with solders by varying the proportions of the metals. Solders with low melting points are obtained from mixtures of lead, tin, and bismuth. High-quality solders for electric work consist largely of tin

Commercial solder comes in bars, wire, ribbon, or hollow wire containing the flux inside. Hard solders, or spelter solder, contain copper and zinc, and have higher melting points. They are used with the blowpipe and are in reality brazing alloys. Solders with nickel content are used for soldering German silvers, and silver and gold solders are used for jewelers work. Silver solder in varying proportions is also used as a high-melting-point solder for general work. A standard solder for all-around work contains 48 per cent of tin and 52 per cent of lead. It melts at 360 deg. F. A similar solder, but with 45 per cent of tin and 55 of lead, melts at 465 deg. F. A "cheap" solder contains 25 per cent of tin, and 75 of lead. The high-lead solders run with difficulty and do not adhere as well as the tin solders. See also Plumbers' solder, Cadmium solder, Bismuth solder, Silver solder.

Solidified alcohol. A trade designation for a jelly-like mixture of alcohol and nitro-cellulose, or "soluble cotton." When dissolved in alcohol the nitro-cellulose burns without exploding. Solidified alcohol is usually put up in tins, and is employed for heaters and small stoves.

Soluble oils. Oils made soluble by treatment with sodium hydroxide or other alkali, either by direct mixture, or by the addition of soaps to the oil. Oils thus treated emulsify readily because of the formation of sodium oleate and sodium palmitate, and are mixed with water for use in pumping over the work being machined in rapid production machines. The presence of about 1 per cent of sulphur is important. Sulphonated lard oil is used to bring up the sulphur content. Pine oil or oil of sassafras is added to improve the odor. Cresol is added for disinfecting. Rosin or rosin oil is added to form sodium resinate to improve the cutting qualities. Soluble oils are used mainly for keeping the work and cutters cool, but they also exert a lubricating action between the cutting edge of the tool and the work, thus decreasing the friction of cutting. In machines having hardened and ground steel spindles the soluble oils are also

used to lubricate the bearings because of the facility of flow and their cooling action. Their disadvantage is that they easily corrode the machine and the work. See also Cutting oils.

Solvents. Liquids having the power of dissolving various materials. The usual commercial solvents for organic substances are the alcohols, ether, benzine, and turpentine. The best solvents for rubber is di-chlor-ethylene, or carbon bisulphide. Turpentine and benzine are the usual solvents for ordinary paints and varnishes containing gums and resins. Amyl and other alcohols amyl acetate, and other very volatile liquids are used as solvents for quick-drying lacquers. Water is a solvent for most acids and many organic and inorganic materials Acids or alkalies that corrode or decompose the material destroying its chemical nature, are not solvents for the material. Solvents are useful industrially as in the case of paints, by "reducing" the material and allowing it to be applied. The solvent is then allowed to evaporate or is removed by heating. They are also used to separate one substance from another, by the choice of a solvent that wil dissolve one without affecting the other.

Sorel cement. A magnesia cement consisting of a mixture of magnesia with a concentrated solution of magnesiun chloride, or it can be prepared by adding water to a mixture of the two dry components. It has considerable strength and is used for cementing glass and metal, and for making artificial stones.

Sorel's alloy. A zinc-copper alloy containing iron, an out of the range of the brasses because of its high zin content. It may contain as high as 98 per cent of zin with 1 per cent of copper and 1 of iron, or it may have a low as 80 per cent zinc with 10 per cent copper, and 1 per cent iron. It is employed for casting small statue or novelties. and is very hard and quite brittle. It canno be rolled or drawn. It is placed with bronze, and markete

as cast bronze. The alloy is prepared by melting brass of known composition and then adding the zinc and cast-iron shavings.

Sound insulators. Materials employed, chiefly in walls, for reducing the transmission of noise of machinery. Insulators are used to absorb the sound, as distinct from padding employed under the machines to prevent the vibrations that cause the sound. For factory use the walls, partitions, and ceilings offer the only mediums for the installation of sound insulators. All material substances offer resistance to the passage of sound waves, and even the glass windows may be considered as insulators. But the term refers to the special materials placed in the walls for this specific purpose. Insulators may consist of mineral wool, hair felt, fiber sheathing boards, or simple sheathing papers. Sound insulators are marketed under a variety of trade names, such as Celotex, made from bagasse, and Linofelt and Fibrofelt, made from flax or rye fiber. Wheat straw is also used for making insulating board. Sound insulators are often also heat insulators.

Soya-bean oil. A pale-yellow oil obtained by expression from the seeds of the plant *Glycine soja*, native to China and Japan. It is used as a substitute for linseed oil for paints and varnishes, or for adulterating linseed oil, although it has only half the drying power of linseed oil. The bean contains up to 19 per cent of oil, of which 12 per cent is extracted by commercial expression. The specific gravity is about 0.925. There are about 280 varieties of the bean listed. The oil is also used in soaps and as an edible oil.

Spanish cedar. Also called Central American cedar, or in Spanish America, simply "cedro", to distinguish it from Paraguayan cedar. It is a soft wood of a light-red color sometimes beautifully figured with wavy grain. It has an agreeable odor. It is easily worked, seasons well, and takes a fine polish. The weight is from 28 to 33 lb. per cu. ft. The tree grows to a very large size, logs being

available 40 in. square. The imports come chiefly from Central America and the West Indies, but the tree grows as far South as northern Argentina. The wood has a great variety of uses, for cigar boxes, furniture, pattern-making, carving, cabinet work, and construction.

Spanish moss. The fiber from the plant *Tillandsia usneoides*, which grows throughout tropical and sub-tropical America, and along the southeastern coast of the United States, hanging from branches of trees. Spanish moss is used for upholstery, and for packing glass and fragile articles.

Speculum metal. An alloy formerly used for mirrors, and also used in optical instruments. It contains 65 to 67 per cent of copper and the remainder tin. It takes a beautiful polish, is hard and tough. It is claimed that true speculum metal is a chemical compound of the formula Cu_4Sn, containing 66.6 per cent of copper. An old Roman mirror contained about 64 per cent copper, 19 of tin, and 17 of lead, while an Egyptian mirror contained 85 per cent of copper, 14 of tin, and 1 of iron. The Ross telescope mirror contains 70 per cent copper and 30 per cent tin.

Spence's metal. This compound of sulphur mixed with metallic oxides is not a metal. It is prepared by introducing iron disulphide, zinc blende, and galena into melted sulphur. One analysis gave the following composition: Iron disulphide 57 per cent, sulphur 32 per cent, zinc sulphide 4 per cent, silicic acid, copper sulphate, and other substances 7 per cent. The color is gray with lustrous dots. It makes clean, full castings, is insoluble in water, and resists well the action of the atmosphere, acids, and alkalies. It is used as a solder for gas pipes, and as a joining material in place of lead. It grips rubber, metals, and stone, and makes a tight joint. The melting point is 320 deg. F., and it expands on cooling.

Spermaceti. The white, crystalline flakes of fatty substance, or wax, that separate out from sperm oil. It differs from ordinary fats in not yielding glycerin when saponified. In the living animal the wax and oil exists as a liquid, and the wax is obtained by boiling and cooling. It is purified by pressing. It is also separated out from dolphin oil. Spermaceti is odorless and tasteless, insoluble in water, but soluble in hot alcohol. It burns with a bright flame. It was formerly used for candles, but now is employed as a fine wax.

Sperm oil. The fatty oil extracted from the head cavity of the sperm whale, *physeter macrocephalus.* The spermaceti is first separated out, leaving a clear yellow oil. It is purified by being pressed in bags at a low temperature. It is graded according to the temperature of pressing. A good grade of sperm oil would have a specific gravity of 0.875 to 0.885, and a flash point above 440 deg. F. Inferior grades of sperm oil are likely to be from sperm whale blubber. Commercial sperm oil is likely to be one-third head oil and two-thirds body oil. Sperm oil differs from fish oil and whale oil in consisting chiefly of waxes, and not fats. Sperm oil absorbs very little oxygen from the atmosphere and is not influenced by variations in temperature. It is therefore valuable as a lubricating oil, and a fine grade of sperm oil, or "jaw oil," is used for delicate mechanisms. A good sperm oil from the head has a specific gravity of 0.877, iodine value of 76, and saponification value of 140. See also Whale oil.

Sperrylite. The only known compound of platinum occurring in nature. It is a rare mineral found in Ontario, Canada, and in Wyoming. Sperrylite is a platinum arsenide, $PtAs_2$, usually found in small grains. It has a hardness of 6 to 7, a specific gravity of 10.6, a tin-white color, and a metallic luster.

Sphalerite. Known also as zinc blende. It is the most important ore of the metal zinc, and is found in quantities in

Missouri and surrounding states. It also occurs in Englanc Switzerland, and Hungary. Sphalerite is a zinc sulphide ZnS, containing theoretically 67 per cent of zinc. Howeve iron may replace the zinc to the extent of 18 per cent. I has a massive crystalline or granular structure, and a hard ness of about 4. When pure its color is white, but color yellow, brown, green, to black with impurities. It is a extremely common mineral. To obtain the zinc the ore i roasted to reduce the sulphide to an oxide, and then "dis tilled" with carbon in retorts. The metal is refined b remelting and settling the lead and iron, or by redistilling

Spiegeleisen. A pig iron containing usually from 15 t 30 per cent of manganese, used for making manganese ste by the Bessemer process. The German name, meanin mirror iron, is derived from the fact that the crystals of th fractured face shine like mirrors. The carbon content from 4.5 to 5.5 per cent. Spiegeleisen is now largel replaced by ferro-manganese. When spiegeleisen is use for adding manganese to steel, the quantity needed is s great to obtain the required proportion that it must b pre-melted before adding to the steel.

Sponge. The cellular body of a marine animal, of th genus *Spongia*, of which there are various species. It employed for wiping and cleaning, and as it will absorb an hold a great quantity of water in proportion to its weight is valuable for this purpose. Sponges grow like plant attached to the sea bottom. They are prepared for use b maceration in water, and are then beaten and treated wit acids to remove concretions. They may also be bleach chemically. The best sponges come from the Medite ranean and Red Seas, and from the Caribbean Sea. Tarpo Springs, Florida, is the center of the American spon fisheries. Sponges are apt to be loaded with chemicals increase their weight.

Sponge iron. Iron made from ferrous sand and press into briquettes, which can be charged directly into the ste

furnaces instead of pig iron. The process of making sponge iron consists in charging the sand ore continuously into a rotary furnace mixed with coal that has been partially distilled to drive off light volatiles. The temperature of the furnace does not exceed 1,000 deg. C. The iron oxide is reduced to metallic iron, and passes to cooling cylinders, and then through magnetic separators. The finely divided iron is then briquetted at about 50,000 lb. per sq. in. pressure, making briquettes of a density of 75 per cent of that of solid iron. Sponge iron is made on a large scale at Kuji, Japan, from ferrous sands which cannot be used in the blast furnace. The only other sponge iron plant is at Loraine, Ohio.

Sprengle explosives. Chlorate compounds which have been rendered reasonably safe from violent explosion by separating the chlorate from the combustible matter. The potassium chlorate is made up into porous cartridges and dipped just before use in a liquid combustible such as nitrobenzene. See Prométhée and Rack-a-rock. Sprengle explosives were formerly used as military explosives, but are now valued only when it is desired to economize on nitrates.

Spring brass. A good quality of sheet brass rolled 8 numbers hard. See Brass. The name "Spring bronze" is sometimes erroneously applied to brass of this kind, especially if it contains some tin. True spring bronze usually contains about 95 per cent of copper, a small amount of phosphorus, and the balance tin.

Spring steel. An indefinite term applied to any steel used for making springs, but there is no standard steel for springs. Carbon steels, with from 0.50 to 1 per cent of carbon, are much used, but vanadium and chrome-vanadium steels are also employed, especially for car and locomotive springs. The only special requirement for springs is that the steel be low in sulphur and phosphorus. For flat or spiral springs that are not heat-treated after

manufacture, hard drawn or rolled steels are used. Thes may also be tempered in the mill shape. Music wire i widely employed for making small spiral springs. Se Steel.

Spruce. The wood of the coniferous tree *Picea excelsa* of northern Europe and North America. It is exporte from the Baltic region as "white fir," and "white deal. It is also called Norway spruce and spruce fir. The wood i white, and has a straight, even grain. It is tough and elas tic, and is more difficult to work than pine. The weight i 36 lb. per cu. ft. Spruce is used for making paper pul for packing boxes, and as a general utility lumber. Whit spruce is from the tree *Picea alba*, of the United States an Canada. It has quite similar characteristics. Red Spruc *Picea rubra*, is the species found chiefly in the easter United States. Silver Spruce, or "western spruce," from the enormous tree, *Picea sitchensis*, of the wester United States and Canada. It is soft and light in weigh but strong, close-grained, and very free from knots. Th weight is somewhat less than common spruce. Th production of all varieties of spruce in the United States i 1925 was 751,276,000 board feet. Japanese spruce from *Abies mariesii*, and Himalayan spruce is from *Pic morinda*. The latter resembles the common spruce Europe. See also Hemlock spruce.

Sprucolite. The trade name of a compressed spru used for machine pulleys, gears, wheels, rolls, and cuttin die blocks. The material is made from Sitka, or Wester spruce. Sheets of spruce are impregnated with a wate proof binding agent, built into a laminated block with t grains of the laminations at right angles to each other, a then subjected to great hydraulic pressure. The resulti product is dense and hard. The coefficient of friction 40 to 50 per cent higher than that of cast iron, and t weight is only about 35 per cent that of cast iron. Spruc lite is a product of the Sprucolite Corporation, Bloo field, N. J.

Stainless iron. A chromium-iron alloy usually containing from 12 to 20 per cent of chromium, but it may contain as low as 9 per cent. The chromium gives to the alloy the property of being highly resistant to oxidation and corrosion even at elevated temperatures. The Brinell hardness is as high as 320, and the tensile strength is up to 150,000 lb. per sq. in. It differs from stainless steel in having a carbon content below 0.12 per cent. Stainless iron is employed for tank plates, and for parts where corrosion- or acid-resisting qualities are valuable, but where the higher strength and hardness of the stainless steels are not required. Stainless iron does not require heat-treatment, but its physical properties are often improved by such treatment, and it can be hardened, although ordinary steel of the same carbon content will not harden.

Stainless steel. The trade name of a group of carbon steels containing from 12 to 18 per cent of chromium, originally produced in America in 1914 under the English Brearley patent. The original composition was 13.5 per cent of chromium, and 0.35 per cent of carbon. This steel is machinable, has a tensile strength of 150,000 lb. per sq. in., and a Brinell hardness of 325. When quenched in oil from a temperature of 1,750 deg. F. this steel has a tensile strength of 240,000 lb. per sq. in., and a Brinell hardness of 500. It can also be hardened by air cooling from a temperature of 1,825 deg. F. The steel is now also made with a higher carbon content, giving greater hardness. Low-carbon stainless steel with only 12.5 per cent of chromium, is used for turbine blades and pump rods. The higher carbon content steels up to 0.90 per cent are used chiefly for cutlery, and retain a keen cutting edge. Malleable stainless steels are high in chromium but low in carbon. These latter steels do not possess the air-hardening properties of the original stainless steels. Ordinary stainless steels contain about 0.30 to 0.35 per cent of carbon, and can be hardened and tempered. Hardness is necessary to bring out the stainless qualities, and the scale must be

polished off after tempering. A free-cutting stainless stee is made by adding about 0.40 per cent of zirconium sulphide The latter makes the steel easy to machine, and does no impare the resistance to corrosion, but it decreases th ductility, somewhat. "Carpenter stainless No. 5" con tains 14 per cent of chromium, 0.40 of zirconium sulphide and 0.10 of carbon. It can be cold drawn, or forged a temperatures up to 2,100 deg. F. It is hardened by quench ing in oil from a temperature of 1,825 deg. F. The specifi gravity is 7.778. See also Stainless iron.

Standardalloy. The trade name of heat-resistant an acid-resistant alloys produced in several grades by th Standard Alloy Company, Inc., Cleveland, Ohio. The are primarily intended for castings. One grade contair 25 per cent of nickel, 20 of chromium, 0.40 of carbon, 0.2 of silicon, and the balance iron. It is employed for grate and furnace conveyors. One grade for carburizing boxe contains 37 per cent of nickel, 17 of chromium, 0.30 c carbon, and the balance iron, while another contains 60 pe cent of nickel, 20 of chromium, and the balance iron. Th first of these two has a tensile strength of 62,100 lb. per sq. in an elongation of 3 per cent in 2 in., and a Brinell hardness c 177. The specific gravity is 7.71, and it weighs 0.284 ll per cu. in. Standardalloy castings are suitable for us continuously at temperatures up to 2,000 deg. F., and at th temperature have a tensile strength of about 6,300 lb. pe sq. in. For ore-roasting equipment, the nickel is eliminate because of sulphur action, and the castings are of chromium iron, with consequent reduction in tensile strength. Whe great hardness is required, the carbon content is increased a required. Special compositions are used for acid resistanc

Standard phosphor bronze. A bronze containing 80 p cent of copper, 10 of tin, and 10 of lead. The alloy ma contain about 0.25 per cent of phosphorus, as an exce from the phosphorus used as a deoxidizer. This alloy used for casting high-speed bearings used under heav pressures. When chill cast the grain is fine, and the allo

is very hard. The tensile strength of the alloy is 28,000 to 33,000 lb. per sq. in., elongation in 2 in. 6 to 9 per cent, Brinell hardness 55 to 65, specific gravity 9, and weight 0.325 lb. per cu. inch.

Standard sand. The product known as "standard sand" is a silica sand used in making concrete and cement tests. The grains are free of organic matter, and will pass through a 20-mesh sieve, but will be retained on a 30-mesh sieve.

Stannum metal. The trade name of a high-tin babbitt used for machinery bearings. It is a product of the Lumen Bearing Company, Buffalo, N. Y.

Staralon. An artificial silicon carbide used as an abrasive. It is a product of the Detroit Star Grinding Wheel Company, Detroit, Mich. See Silicon carbide.

Staralox. An artificial corundum made in the electric furnace. It is a product of the Detroit Star Grinding Wheel Company, Detroit, Mich. See Aluminum oxide.

Starch. A large group of substances with the empirical formula $(C_6H_{10}O_5)x$, and occurring widely in grains, tubers, and fruits. They are used industrially for pastes, adhesives, fillers, explosives and stiffening materials. The common cereal grains contain from 55 to 75 per cent of starch. Potatoes have about 18 per cent of starch and 78 per cent of water. Most of the commercial starch is made from corn. The starches from different plants have similar chemical reactions, but all have different granular structure. In general starch is a white, amorphous powder having a specific gravity from 0.499 to 0.513. It is insoluble in cold water. When boiled with water starch produces a paste, and is often used in cooking. Starch is also added to baking powder, salt, and other food products, and toilet powders to keep them dry since starch has an affinity for water. Soluble starch is made by allowing starch to stand in contact with cold, dilute acid for some days. Dextrine

is a starch with a smaller value of x in the molecule, and i made by heating starch in a dry condition. Starch give a blue color with iodine, while the dextrines give viole and red. Dextrines have a sweet taste. Dextrine ha adhesive properties and is used on envelope flaps and postag stamps. Animal starch, or "glycogen," is the reserve foo of animals, stored in the muscles and internal organs. Gree fruits, especially bananas, often contain much starch, whic makes them indigestible until the ripening process ha changed the starch to sugar.

Statuary bronze. Copper alloys used in making cas statues. Most of the famous large bronze statues c Europe contain from 87 to 90 per cent of copper, with widel varying amounts of tin, zinc, and lead. A general averag statuary bronze will contain 90 per cent of copper, 6 of tir 3 of zinc, and 1 per cent of lead.

Staybrite. The trade name of a rust-resistant malleab steel made by Thos. Firth & Sons, Ltd., Sheffield, Englan Unlike most chromium steels, it is claimed to be easil cold pressed or riveted. See Stainless steel.

Steam bronze. An alloy containing usually about 8 per cent of copper, 5 of zinc, 5 of lead, and 5 of tin. It used for valves and fittings. The tensile strength vari from 26,000 to 32,000 lb. per sq. in., elongation from 16 to 2 per cent, and reduction of area from 20 to 25 per cent. I casts well and is homogeneous and ductile. It takes a fir polish. Practically the same alloy is used for automobi parts.

Stearic acid. A hard, white, wax-like substance used f making paint driers and waterproofing compounds. It the common constituent of hard fats, and is a white mass the composition $CH_3(CH_2)_{16}COOH$, soluble in alcoho but insoluble in water. The specific gravity is 9.84 melting point 69 deg. C., and boiling point 291 deg. C. It obtained from fats and oils by "splitting" and distillin

or it can be made from oleic acid by hydrogenation. Stearic acid is also used for making candles, usually mixed with palmitic acid or paraffin.

Steel. A chemical compound of iron and carbon, with no carbon in the free state. Its strength is greater than iron. When raised to a red heat and cooled suddenly it becomes exceedingly hard. Thus hardness can be varied by subsequent heating and cooling. The average weight is 0.283 lb. per cu. in. Steel is graded according to the percentage of carbon in it, the high grades having the most carbon. The usual proportions of carbon vary from 0.50 per cent to 1.5 per cent. Steel containing less than 0.15 per cent of carbon hardens only slightly, while that with more than 1.25 per cent becomes brittle. The low-carbon steels machine easily and can be forged readily, while those containing about 1.0 per cent of carbon are difficult to forge and machine. "Spring steel" is an indefinite name, since many types can be employed for springs, but it usually indicates a steel with very low sulphur and phosphorous. Crucible steel is made by melting wrought iron with charcoal and cast iron. Bessemer steel is made by decarbonizing cast iron by forcing a powerful blast of air through the molten iron. Open-hearth steel is made by fusing cast iron with wrought iron, or with steel scrap, in a regenerative furnace. "Cementation" consists in heating bars of wrought iron in contact with carbon. The product is known as blister steel. The production of steel ingots in the United States in 1927 was 45,897,000 tons, nearly half the world production. Germany is the largest exporter of steel, with 4,887,000 tons exported in 1926. France and Belgium follow. See also Nickel steel, Silicon steel, High-speed steel, Tool steel, Non-shrinking steel, Crucible steel, Cast steel, Bessemer steel, Open-hearth steel, Alloy steel, Machinery steel.

Steelite. A French trade name for a blasting powder which is a form of cheddite. It consists of potassium chlorate, the particles of which are enveloped in oxidized

rosin. It has no apparent advantages over other forms of cheddite. See Cheddite.

Steel wool. Long, fine fibers of steel used for abrasive purposes, chiefly for cleaning utensils and for polishing. It is made from low-carbon Bessemer wire of high-tensile strength, usually having 0.10 to 0.20 per cent of carbon, and 0.50 to 1.00 per cent of manganese. The wire is dragged over a track and shaved by a stationary knife bearing down on it. A special "Brillo-Field" machine also is made for shaving off the wool in a continuous piece and winding it around wheels. Fibers of a length of 100,000 ft. have been made. Steel wool usually has three edges, but may have four or five, and strands of various types are found together. There are nine standard grades of steel wool, the finest of which has no fibers greater than 0.0005 in. thick, and the most commonly used grade having fibers that vary between 0.002 and 0.004 in. The medium grades resemble wool in texture, but the finest grade resembles silk. The American production of steel wool is 3,000 tons annually.

Stellite. The trade name of an alloy used for cutting tools. The cutting properties of this alloy are inherent in the alloy, and are not produced by heat-treatment as with steels. Stellite usually contains from 40 to 55 per cent of cobalt, from 15 to 33 per cent of chromium, from 10 to 17 per cent of tungsten, about 2 per cent of carbon, and small amounts of iron and molybdenum. Other compositions are also used. It has the property of red-hardness similar to high-speed steel. Stellite is silvery-white when polished. It cannot be machined, and must be cast and ground to shape. Stellite tools have a Brinell hardness of about 570 and a tensile strength of about 40,000 lb. per sq. in. They are forged only with difficulty at from 750 to 1,200 deg. C. Stellite does not rust or tarnish easily. It has only about 1.5 per cent of the electrical conductivity of copper. The coefficient of friction of two polished surfaces of Stellite i

0.11, or about half that of almost any other dry metal. It is a product of the Haynes Stellite Company, Kokomo, Indiana.

Stephanite. An ore of silver. It is a sulph-antimonite of silver, $Ag_5 SbS_4$, containing 68.5 per cent of silver, and 15.2 per cent of antimony. It is found associated with other ores of silver in Nevada and in Mexico, Peru, Chile, Saxony, Bohemia, and Hungary. Its hardness is 2 to 2.5, and specific gravity 6.2 to 6.3. It usually occurs massive, in disseminated grains, of an iron-black color and metallic luster.

Sterbon. The trade name of a silicon carbide, SiC, made in the electric furnace, and used as an abrasive. It is a product of the Sterling Grinding Wheel Company, Tiffin, Ohio. See Silicon carbide.

Sterling silver. A trade name for silver containing only a small amount of a hardener. Since silver is a very soft metal, it is not used industrially in its pure state, but is alloyed with a hardener, usually copper. Sterling silver is the name given to a standard high-grade alloy containing a minimum of 925 parts in 1,000 of silver. It is used for the best tableware, and for jewelry. Sterling silver is made by melting the silver and copper together in a crucible using a cover of charcoal to prevent spitting. The 7.5 per cent of copper makes the alloy so hard that it requires annealing between rollings.

Sterling spelter. The name given to a grade of slab zinc. It contains 99.50 per cent maximum of zinc, and 0.10 per cent maximum of lead. The content of other impurities is given as not exceeding 0.03 per cent of iron, and 0.50 per cent of cadmium.

Sterlith. The trade name of an artificial corundum made in the electric furnace, and employed for abrasive purposes. It is a product of the Sterling Grinding Wheel Company, Tiffin, Ohio. See Aluminum oxide.

Stibnite. The chief ore of the metal antimony. It is antimony trisulphide, Sb_2S_3, containing 71.4 per cent of antimony, with sometimes gold or silver. It occurs in slender prismatic crystals of a metallic luster and lead-gray color. It has a hardness of 2. The antimony is obtained by melting the stibnite with scrap iron, forming FeS and liberating the antimony. Another method is to roast the ore to produce Sb_2O_4 and then reduce to the metal with carbon. Stibnite comes from China, Japan, Germany, Mexico, and New South Wales, with a little in the western United States. For pyrotechnic uses stibnite is "liquated" by melting the mineral and drawing off the liquid. On cooling it solidifies, and this product is ground.

Stillingia oil. A drying oil obtained from the kernels of the seeds of the tree *Stillingia sebifera*, largely cultivated in China. The seeds contain about 23 per cent of a light yellow oil resembling linseed oil, but of somewhat inferior drying power. The oil has a specific gravity of 0.943 to 0.946, and iodine value of 160. It has the peculiar property of expanding with great force at the congealing point. Stillingia oil is edible, but deteriorates rapidly, becoming bitter in taste and disagreeable in odor. Stillingia tallow, also known as Chinese vegetable tallow, is obtained by pressing from the coating, or mesocarp, of the seeds. Sometimes the whole seed is crushed, producing a softer fat than the true tallow. The tallow is composed chiefly of palmitic and oleic acids, and is used for adulterating wax, and in soaps.

Strontium. A metallic element of the alkaline earth group. Its chemical symbol is Sr. It occurs in the minerals strontianite and celestite, the carbonate and sulphate of strontium, respectively. It resembles barium in its properties and combinations. Its color is pale-yellow. The specific gravity is 2.54, melting point about 900 deg. C., and it decomposes water. It is obtained only with difficulty in its metallic state, and has as yet no commercial use

as a metal. Strontium compounds are sometimes used as deoxidizers in alloys of copper, tin, zinc, and lead.

Strontium nitrate. A yellowish-white, crystalline powder of the composition $Sr(NO_3)_2$. It is the strontium salt of nitric acid, and is prepared by roasting celestite, leaching out the strontium sulphide, and dissolving the strontium carbonate in dilute nitric acid. The yellowish commercial product is 99.5 per cent pure. It is soluble in water, but insoluble in alcohol. The specific gravity is 2.96, and melting point is 645 deg. C. Strontium nitrate gives a beautiful crimson flame, and is used in red-lights, railway-signal flares, and signal stars. It also furnishes the oxygen necessary for the combustion of the compounds. A typical flare compound contains 50 per cent of strontium nitrate, 37½ of potassium chlorate, and 12½ of shellac, the latter serving as a binder and to furnish heat of combustion for the flame.

Sulphonated oil. A fatty oil that has been treated with sulphuric acid, the excess acid being washed out, and only the chemically combined acid remaining. The oil is then neutralized with an alkali. Sulphonated oils are "soluble," and are used in cutting oils. Sulphonated castor oil is called Turkey red oil.

Sulphur. An element which occurs abundantly in its uncombined state. Its symbol is S. It is obtained from the gypsum deposits of Texas and Louisiana, and from volcanic deposits in Sicily, Mexico, Chile, and Argentina. It is purified by distillation. It can also be obtained by distillation from iron pyrites. Sulphur forms a crystalline mass of a pale yellow color. Its hardness is 1.5 to 2.5, and specific gravity is 2.05 to 2.09. It melts at 232 deg. F. At about 780 deg. F. it is converted into a ruby-colored vapor. Sulphur also condenses in light flakes, in which form it is known as flowers of sulphur. The amorphous sulphur has a specific gravity of 1.955. When melted and cast into sticks it is known as brimstone. Sulphur has a

great affinity for most metals, and combines with great energy when heated together with them. Sulphur, even in very small quantities, makes metal alloys very brittle, and must be kept out of commercial metals. Sulphur has many uses in the formation of sulphur compounds and sulphuric acid, for making gun powder, for vulcanizing rubber, for bleaching cloth, as a fumigant, and in medicine. It is also used as a cement for fastening iron and stone. Commercial crude Sicilian sulphur contains from 2 to 11 per cent of impurities, and is sold in three grades. The 1927 output of Sicilian sulphur was 231,441 metric tons.

Sulphur dioxide. Also known as sulphurous acid anhydride. It is colorless gas of the composition SO_2, employed for industrial bleaching, as a preservative, and in refrigeration. It has a suffocating odor, is poisonous, and very corrosive. It boils at −10 deg. C. It is soluble in water, forming sulphurous acid. Sulphur dioxide is produced by roasting pyrites in a furnace. Sulphurous acid is a colorless liquid of the composition H_2SO_3, with suffocating fumes. It is made commercially by absorbing the sulphur dioxide gas in water. The U.S.P. grade has a strength of 6 per cent. Sulphurous acid is used in industrial bleaching of all kinds.

Sulphuric acid. Also called in the trade oil of vitriol. An oily liquid of the composition H_2SO_4, used for pickling and cleaning metals, for making explosives, for bleaching oils, in electric batteries, and for various other purposes. The specific gravity is 1.834, and boiling point 210 deg. C. It is miscible in water in all proportions. The color is yellowish to brownish according to the purity. Sulphuric acid is made by various processes from pyrites, or by oxidizing the sulphur dioxide from the waste gases of copper and zinc smelters and absorbing the gas in water. The common commercial grade known as oil of vitriol is 66 deg. Bé., which is 93.2 per cent acid. Other grades are 5[illegible] and 60 deg. Bé. Sulphuric acid is highly corrosive. The dilute acid does not dissolve lead or mercury, however.

disintegrates wood, rubber, and other organic materials. "Niter cake," which is sodium acid sulphate, $NaHSO_4$, contains 30 to 35 per cent of available sulphuric acid, and is used in hot solutions for pickling and cleaning steel articles. It comes in colorless crystals or white lumps, of a specific gravity of 2.435, and melting at 300 deg. Centigrade.

Sunnee. Also known as brown Indian hemp. A fiber obtained from the plant *Hibuscus cannabinus*, of India, and used as a substitute for hemp. It is distinct from sunn hemp, which is obtained from a leguminous plant.

Sunn hemp. The fiber of the plant *Crotalaria juncea*, of India. It is used for cordage and rope in place of jute, but is lighter in color, and is more flexible and stronger than jute. It resembles true hemp. The plant, which is a shrub, is cultivated extensively in India. It grows to a height of about 8 ft., with slender branches yielding the fiber. The method of extraction is the same as for true hemp. The best fibers are retained locally for making into cloth. Sunn hemp is also called Indian hemp, while Madras hemp is from another species of the same plant.

Sycamore. The wood of the tree *Acer pseudo-platanus*, which is also classed as a kind of maple, especially in England. The species cut as sycamore in the United States is *Platanus occidentalis*. The wood has a close, firm, tough texture, and is yellowish in color. The weight is about 38 lb. per cu.ft. The surface is lustrous and takes a fine polish. It is used for veneers, flooring, furniture, and for handles and rollers. The production of sycamore in the United States in 1925 was 24,286,000 board feet.

Synthetic resins. A large group of materials, mostly condensation products, employed for the molding of electrical and mechanical parts such as handles, insulators, panels, and knobs. These resins are usually mixed with wood flour, mica, or some other "filler," and molded with heat and hydraulic pressure. The earliest and best known of the synthetic resins are the phenol-formaldehyde condensation

products. The casein plastics form another group, but are not as suitable for mechanical articles. Phenol and furfural are also employed. Hexamine or urea may also be substituted for formaldehyde. Cumerone forms another group of resins. Phthalic anhydride is also combined with glycero to form a class of resins. The synthetic resins are marketed under many trade names such as Bakelite, Glyptal, Indene, Acrolite, Durite, Pollopas. See Cumerone resins, Pheno resins, Furfural.

Talc. A soft, friable mineral, oily and yielding to the touch. It is used as a filler and glazing material, althoug its chief use is in cosmetics. It is a hydrated magnesium silicate of the composition $4SiO_2 \cdot 3MgO \cdot H_2O$, occurring i laminated plates. The color is white, gray, green, brown, o red. Talc has a hardness of 1, and a specific gravity of 2.8 It has a pearly to greasy luster. It is known as asbestin and other trade names when used as a filler in paints Talc is a secondary mineral formed from magnesium silicates It sometimes found as soapstone. The mineral occurs i the Appalachian region from Vermont to Georgia. "Frenc chalk" is a high-grade talc used for marking.

Talckene. The trade name of a red shale containin enough fine mica to give it a talc feel. It is produced i Pennsylvania, and when ground is used as a pigment an as a paint filler.

Tallow. A general name for the heavy fats obtaine from all parts of the bodies of sheep, oxen, cows, and calves The best grades of internal fats, particularly the kidney fa are used for edible purposes, but the external fats are widel employed industrially for lubricants, for adulterating waxe and vegetable fats, in soaps and candles, for treating leathe and many other purposes. The finest qualities of the catt fats are known as premiere jus, and its products, oleo an stearine, are used in the manufacture of margerine an various food products. The edible grades are white pale yellow in color, almost tasteless, and free from di

agreeable odor, but the non-edible grades are yellow to brown. The tallows consist largely of stearic, palmitic, and oleic acids.

Tamarack. The wood of the American larch tree, *Larix laricina*, of the United States and Canada. It resembles European larch, but is considered to be harder and tougher. It has a yellow color, and the grain is fine and even. The weight is about 40 lb. per cu. ft. It is employed for posts, piles, crossties, and various construction work. See Larch.

Tampico. A stiff, hard, but pliant fiber obtained from the leaves of a species of agave, or "century plant," of Mexico, and employed for the manufacture of ordinary grades of brushes. The fiber is extracted in a similar manner to that for sisal hemp. Tampico fiber is approximately the same as istle fiber, and the fibers of different lots may vary due to differences in the plant species. The color is yellowish-white.

Tannins. Materials used for the treatment of skins and hides to convert them partially or completely into leather. "Green" or raw hides offer little resistance to decay or bacteria, lose their pliability, and become brittle. The tannins change the hides chemically and make them capable of resisting decay and more pliable. Tannins may be natural or artificial. The natural tannins, which are extracts from plants or trees, include quebracho, hemlock bark, mangrove bark, dividivi, myrobalans, chestnut, oak, wattle, valonia, sumac, and cutch. Nutgalls are plant excrescences caused by the punctures of insects. The galls contain 50 to 60 per cent of tannins. They come from the oaks of Europe and from the sumac of Japan and China. The important constituent of commercial tannins is tannic acid. Certain leathers, like sharkskin, are tanned with alum. Others are tanned with chromic acid. Synthetic tannins, called syntans, are largely condensation products made by condensing sulphonic acid with formalde-

hyde. Neradol D is the most commonly used of th syntans, and is made in this way. See also Leather.

Tantalite. The most important ore of the metal tantalum When pure its composition is $FeO \cdot Ta_2O_5$. It occur usually as a black crystalline mineral with a specific gravit as high as 7.3. It is found in Australia, in Connecticut and in Dakota. American tantalite contains only from 10 to 40 per cent of tantalic oxide, Ta_2O_5, while the Austra lian ore contains up to 70 per cent. The mineral ofte contains manganese, tin, and tungsten, and the tantalun is sometimes replaced by neobium, or columbium, whicl bears a close resemblance to it. Tantalite also contain 0.01 per cent of the rare metal germanium.

Tantalum. A white, lustrous metal resembling platinum It has a specific gravity of 16.6, and a very high meltin point, 2,770 deg. C. It is a very ductile metal, and ca be drawn into extremely fine wire. The tensile strengt is as high as 130,000 lb. per sq. in. It is resistant to man acids, and is not dissolved by aqua regia. It will dissolv in a mixture of nitric and hydrochloric acids. Tantalur becomes brittle on heating. It can also be hardened b the addition of silicon, and when hard it is almost impossibl to bore it with a diamond drill. Tantalum is used as filament in electric light bulbs and radio tubes. It i cheaper than platinum, and is sometimes substituted fo it for making chemical apparatus, surgical instrument and tools. Its hardness and non-corrosive qualities als make it useful for pens and instruments. It is on th market in the form of wire from 0.002 in. in diamete upward, in sheets from 0.001 in. in thickness, and in speci shapes and tubes. The ore of tantalum, tantalite, occu in fairly large deposits in Western Australia and in Rhodesi

Tantiron. The trade name of a corrosion-resistant an acid-resistant iron used in cast form for chemical apparat and machine parts where these properties are require It contains a very high percentage of silicon, and fair

high percentages of manganese and carbon. It is brittle, and cannot be machined or forged. It is a product of the Bethlehem Foundry and Machine Company.

Tar. A black solid mass obtained in the distillation of coal. When coal is heated to redness in an enclosed oven it yields volatile products and the residue coke. Upon cooling the volatile matter, tar and water are deposited, leaving the coal gases free. Various types of coal yield tars of different qualities and quantities. Anthracite gives little tar, while cannel coal yields large quantities of low-gravity tar. In the manufacture of gas the tar produced is a viscous black liquid containing 20 to 30 per cent of free carbon, and is rich in benzene, toluene, naphthalene, and other aromatic compounds. In the dry state this tar has a specific gravity of about 1.20. Tar is also produced from coke ovens, and as a by-product of blast furnaces using coal as a fuel. Coal tars are usually distilled to obtain the aromatic substances, and the residue tar, known as "treated tar," or "pitch," is used for making roofing, for road making, and for bituminous paints and waterproofing compounds. It is marketed in wooden barrels. The lightest distillate of coal tar, benzol, is used as an automotive fuel and gives greater mileage than gasoline. Naphthalene and anthracene are the heaviest distillates. Tar is also obtained as a by-product in the destructive distillation of pitch-pine wood. Pine tar is a black viscous mass, and is used for roofing. It is also sometimes called pitch. Wood tar from the destructive distillation of other woods is a dark brown viscous liquid used as a preservative, deriving this property from its content of creosote. Tarvia is the trade name of a refined coal tar, marketed by The Barrett Company in various grades. Tarmac is practically the same material marketed by the American Tar Products Company.

Taylor process wire. Very fine wire made by the process of drawing in a glass tube. The process is used chiefly for obtaining fine wire from a material lacking ductility,

such as antimony, or extremely fine wire from a ductile metal. The procedure is to melt the metal or alloy into a glass or quartz tube, and then draw down this tube with its contained material. Wire as fine as 0.00004 in. in diameter is made commercially by this process. Wires of this kind can be obtained only in short lengths, but since they are used only for electrical instrument and laboratory work this is not ordinarily an objection. The usual length is 12 inches.

Teak. The wood of the tree *Tectona grandis*, of Southern Asia. It is shipped from Burma in very large logs. It resembles oak in appearance, and is strong and firm. It contains an essential oil which gives it a pleasant odor, and makes it immune to the attacks of ants and other insects. It is used for boxes, chests, and in boat-building. The color is golden-yellow, the grain is coarse and open, and the surface is somewhat greasy to the touch. The weight is about 45 lb. per cu. ft. In Burma large plantations grow teak for export.

Tear gases. The popular name for an important group of lachramatory poisons used in chemical warfare. They have a powerful irritating effect on the eyes, producing temporary blindness by a continuous flow of tears and swelling of the eyes. The chief advantage is that only small quantities are required, one part in 10 million parts of air being sufficient to disable a man. One lachramatory shell can have the same disabling effect as 500 phosgene shells, although the effect is usually only temporary. Most of the tear gases, except acrolein, are also poisonous, having after effects, and such gases as chloropicrin are highly lethal. The tear gases include: Chloropicrin, bromoacetone, benzyl chloride, benzyl bromide, ethyliodo-acetate, cyanogen chloride, phenylimino-phosgene, martonite, bromobenzyl cyanide, and xylyl bromide.

Tellurium. A rare elementary metal, symbol Te, obtained pure as a dark-gray powder by the reduction

of tellurium oxide. Its specific gravity is about 6.2, and the melting point about 450 deg. C. It has as yet no use in metallurgy.

Temperite alloys. The trade name of a group of alloys of lead, tin, and cadmium, having definite melting points between 300 and 625 deg. F., in steps of 25 deg. F. They are used to indicate temperatures for tempering steel, instead of depending upon the color method. The alloys are furnished in strips, 10 by 3/16 by 0.030 in. in size. The strip is rubbed on the tool being tempered, or small pellets are cut off and placed on the tool. As the alloys melt within 3 to 5 deg. of a given temperature, the correct heat of the tool can be judged. The tool is then kept at the heat for 5 minutes, each additional minute softening the tool as much as one degree rise in temperature. For accuracy within a given range two alloys are used, one melting 25 deg. below the temperature of the other. Temperite alloys are products of the Cornish Wire Company.

Tensilite. The trade name of a manganese bronze, which is in reality a brass containing aluminum, manganese, and iron. The composition varies, but a typical analysis is: Copper 63.92 per cent, zinc 29.13 per cent, manganese 2.45, aluminum 3.13, iron 1.14, tin 0.16, lead 0.07 per cent. The tensile strength of the cast metal approaches 100,000 lb. per sq. in., and the elongation is 16 per cent in 2 in. Tensilite is a product of the American Manganese Bronze Company.

Terne plate. Common, black, soft-steel plate containing on each side a thin coating of an alloy of 80 per cent of ead and 20 per cent of tin, although other proportions may be used. Commercial terne plate usually comes in boxes of 112 sheets, 14 by 20 in., weighing about 115 lb. Terne plate is made by the hot dip process using palm oil s a flux. It is used for roofing, construction work, and to eplace the more expensive tin plate, where it is not necesary to have the poisonous lead in contact with foodstuffs.

Terra-cotta. A general English term applied to fired unglazed, yellow and red clay wares, but in the Unite States it refers particularly to the red and brown squar and hexagonal tiles made from common brick clay, alway containing iron. Some special terra-cottas are nearl white, while for special architectural work other shade are obtained by dyes. The clays are washed, and onl very fine sands are mixed with them in order to secure fine open texture and smooth surface. Terra-cotta is use for roofing and for tile floors, for hollow building blocks and in decorative construction work. Good, well-burne terra-cotta cannot be more than 1½ in. thick. Terra cotta is very light, weighing 120 lb. per cu. ft., and wi withstand fire and frost.

Tetra-chlor-ethane. A colorless liquid of the chemica formula $CHCl_2 \cdot CHCl_2$, employed as a solvent for organi compounds such as oils, resins, and tarry substances. I is also an excellent solvent for sulphur, phosphorus, iodine and various other elements. It is also used as a pain remover and bleacher, as an insecticide, and in the produc tion of other chlorine compounds. It is also called acetylen tetrachloride, and is made by the combination of chlorin with commercial acetylene in the presence of antimon pentachloride. Tetra-chlor-ethane boils at 144 deg. C freezes at -36 deg. C., and is non-inflammible. It has specific gravity of 1.601, at 15 deg. C. It is narcotic an toxic, and the breathing of the vapors is highly injuriou Mixed with dilute alkalies it forms explosive compound In the presence of moisture it is very corrosive to metal Mixed with zinc dust and sawdust it is employed as a smok screen in warfare.

Tetraethyl lead. A liquid of the composition $Pb(C_2H_5)$ which is used to mix with gasoline to lower the rate explosion in order to prevent the knocking of the engin from the hammer-like blows of sudden explosions. It volatile, and the fumes are very poisonous. Only minut

quantities are dissolved in the gasoline, and the latter is then always colored with dyes for identification. See Ethyl gasoline.

Tetralin. A transparent, white liquid of the empirical formula $C_{10}H_{12}$. It is a substitute for turpentine, and is employed as a solvent for fats, oils, and resins. It burns with a clear flame, and can also be used as a motor fuel. The specific gravity is 0.975, boiling point 206 deg. C., melting point −28 deg. C., and flash point 78 deg. C. It is stable at ordinary temperatures. Tetralin is made by the hydrogenation of naphthalene. "Tetralin extra" is a mixture of tetralin and decalin.

Tetra-nitro-aniline. Commonly known as TNA. A high explosive derived from benzene by a complicated process of nitration. TNA is the strongest of all solid high explosives. It is a fine crystalline powder varying in color from greenish-yellow to olive green. It is insoluble in water, but soluble in acetone. The chemical formula is $O_2N{\cdot}NH_2(NO_2)_3$. It melts at a temperature of about 215 deg. C. The specific gravity is 1.867. It stains the skin a yellow color, but is not poisonous. TNA is more sensitive to shock than TNT, and will be detonated by a rifle bullet. Due to its high cost TNA has only a limited military and commercial use as an explosive.

Tetryl. A high-explosive compound of the same class as TNT and TNA. It is also known as pyronite. Tetryl is an aromatic nitro derivative of benzene, and chemically is called tetra-nitro-methyl-aniline. It is a fine, crystalline yellow powder, insoluble in water, but soluble in benzene and acetone. It melts at 130 deg. C., and explodes when heated to 186 deg. C. It is not hygroscopic. Tetryl is made by nitrating benzene with a mixture of nitric and sulphuric acids, reducing with iron and muriatic acid to aniline, and then combining with methyl alcohol. The resulting dimethylaniline is again nitrated, and the tetryl separated out. The formula is $O_2N{\cdot}N{\cdot}O_2N{\cdot}CH_3(NO_2)_2$.

Tetryl is more sensitive to shock than TNA, and has a rate of detonation higher than TNT. Tetryl is too sensitive to be used as a shell filler, and is employed as a booster explosive. It is highly poisonous.

Thallium. A rare metallic element, symbol Tl. The metal resembles lead, is soft and malleable, and melts at 570 deg. F. At about 600 deg. F. it ignites and burns with a green light. Its specific gravity is about the same as lead. It is dissolved by nitric and by sulphuric acids. Thallium is capable of forming alloys with many other metals. The metal occurs in copper and iron pyrites and zinc ores, and the chief source is the flue-dust of smelters of these minerals. The salts of thallium are highly poisonous. Thallium oxysulfide is used in light-sensitive cells. It is also sensitive to infra-red rays, and can be used for "dark signalling."

Thermalloy. The trade name of a temperature-sensitive magnetic alloy used for magnetic shunts in watt-hour meters for the compensation of errors due to variations in temperature. It contains approximately 66.5 per cent of nickel, 30 of copper, and 2 per cent of iron. The permeability falls off with increase in temperature. By varying the composition and heat-treatment different characteristics can be obtained. The same name is applied to a heat-resisting alloy used for cast boxes for annealing and heat-treating steel. They are products of the Electro Alloys Company, Elyria, Ohio.

Thermit. The trade name of a mixture of finely divided aluminum and very pure iron oxide, which when ignited reacts to produce a superheated steel at a temperature of about 5,000 deg. F. The reaction depends upon the affinity of oxygen for aluminum. Up to a temperature of 2,800 deg. F. thermit is inert, but above that temperature the oxygen of the iron oxide unites with the aluminum, setting free the iron in molten form. It is used for welding of heavy pipes and large sections of iron or steel. Railroad thermit is plain thermit with the addition of 17 per cent

of nickel, manganese, and mild-steel punchings. This grade is used for all steel welds. Cast-iron thermit is plain thermit with 3 per cent of ferrosilicon and 20 per cent of mild steel punchings. It is used for welding together cast-iron parts. The thermit is melted by the heat of its own chemical reaction, and the resulting molten steel is poured around the joint to be welded, forming a solid fusion weld. The combustion is started by means of a gas torch, or with a special powder.

Thorite. A rare mineral which is a source of thorium. It is found chiefly in Norway. Thorite is a thorium silicate, $ThSiO_4$, sometimes also containing uranium. It occurs in crystals or massive, with a resinous luster and color orange, brown, or black. The specific gravity is 4.8 to 5.2, and the hardness is 5 on the Moh scale.

Thorium. A rare metal which, in the form of its nitrate $Th(NO_3)_4$, is used in the manufacture of incandescent gas mantles. The metal has never been obtained in a pure state due to its high melting point and the ease which it combines with oxygen. The oxide, thoria, ThO_2, was discovered by Berzelius in 1828. The impure metal is a gray powder with a specific gravity of 11.3. It burns easily in the air with great brilliance. The melting point is placed at 3,090 deg. F. The chief source of thorium nitrate is in the mineral monazite found in Brazil, India, East Africa, and to some extent in the United States. Ceylon monazite usually contains about 10 per cent of thoria, or double that of Brazil. Monazite is a sand varying in color from yellow to dark brown. The thorium is separated from the cerium, ythrium, lanthanum, and other elements in the monazite by a complicated process. The incandescent mantle, invented by Welsbach in 1893, uses a mixture containing 98 to 99 per cent of thorium oxide and 1 to 2 per cent of cerium oxide. The thorium nitrate is converted to the oxide by ignition, with an increase of 10 times its volume. Thorium compounds are also used in flashlight powders.

Tin. A silvery-white lustrous metal with a bluish tinge. The chemical symbol is Sn. It has been employed by man from the earliest times. Tin is soft and very malleable. It can be rolled into sheets as thin as 0.0002 in. It melts at 232 deg. C., and has a specific gravity of 7.298. It is dissolved by mineral acids. When rubbed it gives a peculiar odor, and when bent gives a peculiar cracking, or crying sound. "Tin pest" is the breaking up of the metal into a gray powder. This action begins below 18 deg. C. Tin is used as a protective coating for other metals against corrosion, as a solder, and very largely in making up bronze alloys and babbitt bearing metals. Native tin is rare. The chief source is the oxide, cassiterite, which contains about 86 per cent of the metal. The principal tin producing countries are Bolivia, the Dutch East Indies, and the Malay Peninsula. The United States consumes more than 50 per cent of the world production of tin, and imported 76,640 tons in 1925. Sixty per cent of the tin used goes into tin and terne plate. Of the 140,000 tons of tin produced in 1925, 60 per cent was produced in the Malay States and Dutch East Indies and 21 per cent in Bolivia. The 1927 exports from British Malaya amounted to 83,773 long tons. The "standard tin" of the London Metal Exchange must contain over 99.75 per cent of tin.

Tin foil. Very thin sheet tin used for wrapping confectionery and food products. It was formerly also used for wrapping other materials, but due to its high cost has been largely replaced with aluminum and lead foils. Tin foil is made in thicknesses from 0.006 mm. (0.00024 in.) to 0.200 mm. (0.00787 in.), the former having 16,037 sq. in. per lb. and the latter 432 sq. in. per pound.

Tin plate. Common, black, soft-steel plate containing a thin coating of pure tin on both sides. Commercial tin plate comes in boxes of 112 sheets, 14 × 20 in., and is designated by the net weight per box when below 100 lb. Heavy tin plate above 100 lb. goes by number and letter symbols. The weight of tin is usually 1.5 to 1.7 per cent of the tota

weight of the plate. Tin plate is made by the hot-dip process using palm oil as a flux. Sixty per cent of the tin used in the United States goes into tin plate and terne plate. A total of 8⅓ billion cans were manufactured from tin plate in 1925. "Taggers" is a trade name for tin plate which is undersized, or below the gage of the plate in the package. It is also applied to light-gage plate. These sizes are No. 38 gage, 55 lb.; No. 37, 60 lb.; and No. 36 gage, 65 pounds.

Tissier's metal. A trade name for a high-copper brass containing arsenic as a hardener. It is used for bearings. It contains 97 per cent of copper, 2 per cent of zinc, and 1 per cent of arsenic.

Titanium. A metallic element, symbol Ti, discovered in 1791. It occurs in a great variety of minerals. Its chief commercial ores are rutile and ilmenite. In rutile it occurs as an oxide. It is an abundant element, but is often considered as a rare metal due to the difficulty of separating it. It has a strong affinity for oxygen, hydrogen and carbon. The pure metal has a silvery-white color and is extremely hard, cutting glass with ease. It can be forged when red hot, but when heated to 600 deg. C. in oxygen burns to titanic oxide. Its melting point is very high, 3,272 deg. F., but it dissolves easily in molten copper. The specific gravity is 4.50. Titanium is used for deoxidizing and purifying steel in the form of ferro-titanium. It is also used in alloy steels. It is alloyed with copper as titanium copper. Its salts are used in arc-lamp electrodes, as mordants in dyeing, for yellow coloring of ceramics, and for pigments.

Titanium-copper. An alloy of titanium and copper employed for adding to molten metals as a deoxidizer. It is made by first melting the copper and dropping in the correct amount of titanium inclosed in a copper cup. In alloying, the copper foams greatly. Titanium-copper cannot be poured owing to its great viscosity, but is congealed around a shaft and broken when cold.

Tobin bronze. The trade name of a 60–40 brass contain-ing about 2 per cent of tin. The original Tobin bronze contained 58.22 per cent copper, 39.48 zinc, and 2.30 tin It can be forged and stamped at red heat. It also is resistant to the corrosive action of sea water. It is a product of the American Brass Company. Tobin bronze is also widely used for welding cast iron. The welding rods have a melting point at 1,625 deg. F., and a tensile strength of 54,000 lb per sq. inch.

Toluene. Also called methyl-benzene, and toluol. A liquid of the composition $C_6H_5CH_3$, resembling benzene It is obtained from coal tar and from heavy coal-tar dis-tillates, and is the basis of many dyes, explosives, and aro-matic compounds. Toluene is also obtained by distilling sulphite turpentine with aluminum chloride in the presence of hydrochloric acid. It has a specific gravity of 0.871 boiling point of 110 deg. C., and solidifying point of -9 deg. C. It is inflammable and poisonous. It has an odo distinct from that of benzene.

Tombac metal. A brass containing a high percentage o copper, and not more than 18 per cent of zinc. It has reddish color with somewhat the appearance of gold. Tom-bac generally contains 85 per cent of copper, and the res zinc. It has been used for ornaments since early times i Asia, and is employed for ornaments, buttons, and chea jewelry.

Toncan iron. The trade name of a highly-refined, ver low carbon steel or iron containing small percentages o copper and molybdenum. It is made in various standar forms, and is used for locomotive boiler tubes, and sheet metal work where corrosion-resistant qualities are neede It is a product of the Central Alloy Steel Corporatio Massillon, Ohio. See Ingot iron.

Tool steel. A high-carbon steel used for making tools It has the property of becoming extremely hard by quench-ing from a temperature of 1,400 to 1,800 deg. F. It can the

be "drawn" to any degree of hardness by heating at lower temperatures. The term tool steel does not usually include special alloy steels containing nickel, manganese and other metals, nor high-speed steel, although these are used for tools. Tool steel may contain from 0.65 to 1.50 per cent of carbon, the lower-carbon grades being used for dies, chisels, and other tools requiring some degree of elasticity, and the high-carbon grades are used for punches, drills, and edge-tools. The most common ranges are 0.80-0.90 and 0.95-1.05 per cent of carbon. The manganese content is 0.20 to 0.30. Beyond 1 per cent of carbon, the steels become very brittle when hardened. The lower temperature ranges are used for hardening high-carbon steels and thin pieces, while the steels of about 0.65 per cent of carbon may be quenched from 1,550 deg. F. into water at about 70 deg. F. Edge tools are then drawn by reheating to a temperature of from 400 to 500 deg. F. Oil-hardening tool steels contain about 1 per cent of manganese. Tool steel comes regularly in round, square, and octagon bars, and in flats. Tool steels require more care in forging than low-carbon machinery steels and they are more difficult to machine. See also Non-deforming steel, Finishing steel, Chromium steel, High-speed steel, Hot-die steel.

Toon. The wood of the tree *Cedrela toona* of India, Burma, Java, and Australia. It is called Moulmein cedar in England, and is also known as Indian mahogany. The wood is almost indistinguishable from the Spanish cedar of tropical America. The tree also occurs in Southern Brazil. If seasoned well the wood does not warp, and is durable. It is easily worked and takes a fine polish. The weight is about 35 lb. per cu. ft. The color is a deep red, and the grain has a beautiful appearance. It is used for boxes, cabinet work, furniture, and construction.

Tournay metal. A French high-copper brass used for buttons and cheap jewelry. It has a fine color and is very ductile. It contains 82.5 per cent of copper and 17.5 per cent of zinc.

Trabuk. The trade name of a white alloy used as a substitute for nickel silver. It is claimed to be resistant to the action of vegetable acids. It contains 87.5 per cent o tin and 5.5 per cent of nickel.

Tracing cloth. A thin, fine cotton or linen fabric, o plain weave, and heavily sized and glazed on one side It is used for making tracings in ink, and is quite trans parent. It can also be obtained with the glaze on both sides. Tracing cloth is usually marketed in rolls of 24 yd The sizing is easily soluble in water, and the cloth wil therefore not withstand wetting.

Tragacanth gum. An exudation of the shrub *Astragalu gummifer* of Anatolia, Syria, and Persia, used for adhesives for leather dressing, and as an emulsifying agent. To obtain the gum a small incision is made at the base of th shrub, from which the juice exudes and solidifies. Th gum derived from the first day's incision, known as "Fiori" is the best quality, and is in clear, white flakes. The secon incision produces a yellow gum known as "Biondo." Th third incision produces the poorest quality gum know as "Sari." Rainy weather during the incision period pro duces a still inferior product. Tragacanth is soluble i alkaline solutions, swells in water, and is insoluble in alcoho

Tri-chlor-ethylene. A liquid of the composition CHCl CCl_2, also known as westrosol. It is obtained by heatin tetra-chlor-ethane with milk of lime and distilling in steam Its boiling point is 87 deg. C. and specific gravity 1.471 It is insoluble in water, and is unattacked by dilute acid and alkalis. It is not inflammable and is less toxic tha tetra-chlor-ethane. Tri-chlor-ethylene is a very power ful solvent for fats, waxes, resins, rubber, and other organi substances, and is employed for this purpose. It is also use in soaps employed in the textile industry for degreasing.

Tricresyl-phosphate. A liquid product obtained by th combination of cresylic acid and phosphoric acid. It

used as a camphor substitute in synthetic resins, and as a plasticising medium in lacquers. See Lindol.

Trinitro-toluene. Known commonly as TNT, and also as Trinitrotoluol. The principal constituent of many explosives. TNT was first described in 1863, but not used as a military explosive until 1904. It resembles in appearance powdered brown sugar. The chemical formula is $C_6H_2(CH_3)(NO_2)_3$. It is a powerful explosive, not hygroscopic, and does not form unstable compounds. It melts at about 80 deg. C. The fumes are poisonous, and it is also absorbed through the skin and is a cumulative poison. It is the most stable of high explosives, but is detonated readily with mercury fulminate. A charge of 24 oz. of cast TNT in a 75-mm. shell weighing 9½ lb. breaks up the shell into about 700 fragments. It is also employed for hand grenades, drop bombs, mines, and depth bombs. TNT is made by the nitration of toluene with a mixture of nitric and sulphuric acids. The intermediary product, dinitro-toluene, is employed with hexa-nitro-diphenylamine for torpedoes. A commercial explosive, known as Sodatol, is made by mixing TNT with nitrate of soda.

Tripoli. The name given in commerce to a finely granular, white, porous, siliceous rock, used as an abrasive, and in paints and wood filler. True tripoli is an infusorial diatomaceous earth known in minerology as Tripolite, and is a variety of opal. It is thought to be minute siliceous shelly remains accumulated at the bottom of ancient lakes. It is quarried in Southern Missouri and Illinois, and in eastern Tennessee and Georgia. The Missouri tripoli ranges in color from white to reddish and the crude rock has a porosity of 45 per cent, and contains 30 per cent or more of moisture. It is air-dried and then crushed and furnace dried. Tripoli is used in massive form for the manufacture of filter stones for filtering small supplies of water. A large part of the Missouri tripoli is also used for the manufacture of foundry parting. Tripoli finely ground, free from iron oxide, is

used as a paint filler and in rubber. The grade of tripoli known as O. G. (once ground) is used for buffing composition, D. G. (double ground) for foundry partings, and air-float product for metal polishes. Tripoli compounds are sold under many trade names, and the annual production of tripoli in the United States is about 35,000 tons.

Trojan explosive. A military explosive used for grenades and trench mortar explosives. It contains about 40 per cent of nitrostarch together with ammonium nitrate, sodium nitrate, and small amounts of inert materials added for the purposes of stabilizing and reducing the sensitiveness of the nitro-starch.

T-Stoff. A lachrymatory poison much used by the Germans in gas attacks during the World War. It is a mixture of benzyl bromide and xylyl bromide. Green T-stoff contained 88 per cent of xylyl bromide and 12 per cent of bromoacetone. These substances are colorless liquids, and are thrown in high-explosive shells, disseminating a mist which causes a copious flow of tears. Both substances have a corrosive action on iron, and are inclosed in special lined shells.

Tuc Tur. A non-ferrous corrosion-resistant alloy made by the Tuc Tur Metal Corporation containing 63 per cent copper, 15 per cent nickel, and 22 per cent zinc. Cold-drawn rods of Tuc Tur give an ultimate strength of 80,000 lb. per sq. inch. It is only slightly attacked by sulphuric and hydrochloric acids, alkalies, salts, acid sulphates, or corrosive gases. This alloy is close grained, and takes a high polish.

Tung oil. The most powerful drying oil known, having almost double the rapidity of linseed oil. It is used for lacquers and varnishes. Tung oil is pressed from the seeds of the *Aleurites cordata*, a plant which grows extensively in China and Japan. The seeds contain 53 per cent of oil. The color varies from golden-yellow to dark brown according to the degree of heat used in extraction. It has a

pungent odor resembling that of bacon fat. A good grade of raw tung oil should have a specific gravity between 0.943 and 0.940, a saponification value of 190, and an iodine value of 163. The tree *Aleurites fordii* has also been cultivated in the South of the United States for the production of tung oil. Trees grown in Florida have yielded 30 lb. of oil annually per tree, with 1,800 lb. of oil per acre.

Tungsten. An elementary metal, symbol W. It is never found free in nature. Its commercial ores are wolframite, ferberite, scheelite, and hübnerite. The important sources of tungsten ores are India, Argentina, China, Australia, Europe, and the United States. Tungsten is a heavy white metal with the highest melting point of all the metals. Its specific gravity is 19.6 and melting point 6,060 deg. F. The Brinell hardness is 2.90. It is obtained in powder form by reduction of the oxide WO_3 in a stream of hydrogen. The powder is pressed into rods, then heated to 3,000 or 3,200 deg. C., forming a dense brittle rod. It is worked until it becomes ductile. The tensile strength of rolled sheets is as high as 500,000 lb. per sq. in. Wire drawn to a diameter of 0.0014 in. had a strength of 590,000 lb. per sq. in., the greatest tensile strength of all the metals. It is not attacked by nitric, hydrofluoric or by sulphuric acid solutions. Tungsten wire is used for electric lamp filaments and contact points, but the chief use of tungsten is in high-speed steels and special alloy steels. Tungsten salts are used for bronze powders, and also as mordants in dyeing.

Tungsten carbide. An iron-gray powder of minute cubical crystals, and having the composition WC. The specific gravity is about 16, and the hardness is 9.8 to 9.9, or nearly that of the diamond. The melting point is claimed to be 5,400 deg. F., but if strongly heated it is apt to decompose into W_2C and carbon. Tungsten carbide is produced by carbonizing incandescent tungsten in a methane or hydrocarbon vapor, and other forms may be produced, namely W_2C, W_3C, and W_3C_4. Tungsten carbide is used

as an abrasive, or is briquetted with cobalt or other binder into tools for the high-speed cutting of metal. See als Widia metal, Phoran, and Carboloy. Tungsten carbide i made commercially by the Osram Laboratories, Berlin and by the General Electric Company.

Tungsten paste. Various plastic oxides of the meta tungsten have been employed for the production of squirte filaments for electric lamp filaments. They are covered b English patent 18,814 of 1905, and French patent 357,868 The oxides for this purpose are prepared by boiling hydrate tungsten oxide with ammonia until it crystallises. Th crystals are removed and the residue boiled with water into plastic mass which can then be squirted into filaments The violet oxide W_2O_5, and the brown oxide WO_2 are mos suitable for this purpose. See also Colloidal tungsten

Tungsten steel. Any steel containing tungsten as th alloying element imparting the chief "alloy" characteristic to the steel. It is the oldest of the alloying elements, th celebrated ancient Damascus steel having had tungsten i it. Tungsten increases the hardness of steel. The alloy are difficult to forge, and cannot be readily welded when th tungsten exceeds 2 per cent. When the tungsten content i high, particularly when it contains manganese also, th steel can be hardened by air cooling. Self-hardening steels also known as Mushet steels, are alloys with from 5 to 8 pe cent of tungsten. These alloy steels have a close, uniform texture, and tools made from them can be ground to a fin edge, and will not become dull when the tool becomes re hot. High-carbon tungsten steels retain a high magnetism and are used for making permanent magnets. See als High-speed steel.

Turbadium bronze. The trade name of a mangane "bronze," which is in reality a brass. The compositio varies widely, a typical example containing 47 per cent copper, 46 per cent of zinc, about 2 per cent each of manga nese and aluminum, 1 per cent of iron, and small amoun

of nickel, tin, and lead. It has a high tensile strength, and is claimed to be very resistant to corrosion and to the action of sea water. See Manganese bronze.

Turbiston's bronze. The trade name of an aluminum "bronze," claimed to be highly resistant to the action of sea water. It is a brass containing aluminum and nickel. A typical analysis shows 55 per cent of copper, 41 per cent of zinc, 1 per cent of aluminum, 2 per cent of nickel, 0.84 of iron, and 0.16 per cent of manganese. See Aluminum bronze.

Turkey red oil. A name given to sulphonated castor oil because of its use for the preparation of cotton fiber to be dyed with turkey red. The lower grades of castor oil are employed for making turkey red oil, and are treated with sulphuric acid and washed with a solution of sodium sulphate. Turkey red oil is miscible with water and lathers like a solution of soap. It is soluble, and is employed in cutting compounds.

Turpentine. An oil obtained by steam distillation of the oleo-resin which exudes when the sap-wood of various coniferous trees is cut. It sometimes includes oils obtained by dry distillation. The oleo-resin yields about 20 per cent of oil of turpentine and 80 per cent of residue, known as rosin, or colophony. Turpentine varies in composition according to the species of pine from which it is derived, but consists largely of terpenes. Turpentine is produced commercially in North America, France, Spain, Italy, Greece, Russia and India. Turpentine and rosin are known as naval stores. The American turpentine is produced largely from the long-leaf yellow pine, *Pinus palustris*, of the Southeastern States, and sometimes exceeds 100,000 tons a year. The French production is second in importance. Venetian turpentine is from the European larch tree, *Pinus larix*. Turpentine is unstable and oxidizes on exposure to the air or to sunlight, formic and acetic acids being produced. American turpentine oil boils at 154 deg. C.

Its specific gravity is about 0.860, and its iodine value is ver
high. It is a valuable drying oil for paints and varnishe
due to its property of absorbing oxygen from the atmospher
and transferring it to the linseed oil. It is also used in th
manufacture of artificial camphor, rubber, and perfumes
It is often adultered with petroleum, or other oils of th
pine. See also Wood turpentine, Merkus pine.

Type metal. Any metal used for making printing type
but the name generally refers to alloys of lead and antimony
The latter metal has the property of expanding on cooling
and thus fills the mold and produces sharp, accurate type
Common type metal is composed of 9 parts of lead to 1 o
antimony, but a great variety of other mixtures are also used
The antimony content may be as high as 30 per cent, 1
to 20 per cent being frequent. Larger and softer types ar
made of other alloys, sometimes containing bismuth, whil
the hardest small type contains 3 parts of lead to 1 o
antimony.

Ulcoloy. The trade name of a lead-copper alloy used a
metallic packing for valves where acid-resistance is repaired
It is a product of the United Lead Company. The coppe
is claimed to be distributed uniformly throughout the lea
matrix, hardening and strengthening the alloy. Ordinarily
copper does not alloy well with lead.

Ultramarine. The most important blue pigment, use
in printing and paints. It is also used as a blue for whiten
ing the yellow of paper, starch, sugar, and fabrics. Ultra
marine was formerly obtained by grinding lapis lazul
but is now made artificially by calcining a mixture of alumi
num silicate and sodium sulphide. China clay is used fo
the former. Ultramarine blue crystallizes in the cubi
system. It is ground, and is sold as a deep-blue powde
insoluble in water. Not more than one per cent of th
ground powder should be retained on a No. 325 screen
It may also come mixed with oil, and such a paste shoul
contain 70 per cent of pigment and 30 of linseed oil. It i

a double silicate of sodium and aluminum, $Na_2Al_2SiO_8 \cdot Na_2S$. Green ultramarine is obtained as an intermediate product. White, red, yellow, and violet ultramarines are obtained by various methods. The cheaper grades of ultramarine are apt to be greatly adulterated with gypsum or other materials.

Umber. A brown silicious earth colored naturally with hydrated iron oxides and manganese oxide. It is used as a paint pigment. It comes chiefly from Italy and Cyprus. For use as a pigment it is washed with water and finely ground. It is inert and very stable. Burnt umber is redder in color than umber, and is made by calcining the raw umber. Caledonian brown and Cappagh brown are varieties of umber found in Great Britain. See also Ochre, and Sienna.

Uraninite. Also called pitch blende. It is the chief source of the elements radium and uranium. The mineral is a combination of the oxides of uranium UO_2 and UO_3, together with small amounts of lead, thorium, yttrium, cerium, nitrogen, helium, argon and radium. The gas helium and the rare element radium were first discovered in uraninite. The process of separation of radium is chemically complicated. The structure of uraninite is usually massive or in grains. The color is black, with a pitch-like luster. The specific gravity is 9 to 9.7, and the hardness is 5.5. Uraninite is found with the ores of silver and lead in Saxony, Bohemia, and Hungary, and with tin ores in Cornwall, England. In the United States it occurs in pegmatite veins in Connecticut, and in the mica mines in North Carolina, and in Utah and Colorado. The richest ores come from the Belgian Congo, and the radium is extracted in Antwerp.

Uranium. An elementary metal, symbol U, which belongs to the same group as tungsten and chromium. It never occurs free in nature, but is found chiefly as an oxide. The principal source is from the mineral pitch blende.

where it is associated with radium. The metal was first obtained by Peligot in 1842. Its specific gravity is 18.68, and atomic weight 238.2. The melting point is about 1,860 deg. C. It is a hard, but malleable, metal, resembling nickel in color. It is soluble in mineral acids. The metal is alloyed with iron to make ferro-uranium, used to impart special properties to steel, and as a deoxidizer similar to vanadium. Uranium salts are used to give yellow and orange colors in glazes in the ceramic industry. The properties imparted to steel by small quantities of uranium are stated to be somewhat similar to those given by vanadium and tungsten.

Uranium yellow. Also called yellow oxide. A sodium diuranate of the composition $Na_2U_2O_7 \cdot 6H_2O$, obtained by reduction and treatment of the mineral pitch blende. It is used for yellow and greenish glazing enamels, and for imparting an opalescent yellow to glass, which is green in reflected light.

Valve copper. A general trade name for copper casting alloys used chiefly for making "copper" valves and pipe fittings. It may vary widely in composition, but should cast readily without cracks, checks, or porous spots, and will flow in the mold better than copper. It may contain simply tin, zinc, or lead, or all of these. A composition used by the Parker Appliance Company, Cleveland, is Copper, 88 per cent; tin, 4 per cent; zinc, 3 per cent; lead 3 per cent; and nickel, 2 per cent. It has a tensile strength of 30,000 lb. per sq. in., yield point of 15,000 lb. per sq. in. and elongation of 15 per cent.

Vanadinite. A minor ore of the metal lead and a source of vanadium. It is a rare mineral of secondary origin occurring in the upper oxidized parts of lead veins. It is found in Arizona and New Mexico, and in Mexico and Spain. Vanadinite has the composition $Pb_4(PbCl)(VO_4)_3$ with sometimes phosphorus and arsenic present replacing part of the vanadium. It occurs in crystals and globular

forms, and as incrustations. The specific gravity is 7 and the hardness is 3. The color may be reddish, brown, or yellow.

Vanadium. An elementary metal, symbol V, found widely distributed, but in commercial quantities in only a few places, chiefly Peru and Colorado. The most common ores of vanadium are carnotite, patronite, roscoelite, and vanadinite. About 70 per cent of the commercial vanadium comes from Peruvian patronite and shales, and the reduction is in the hands of one American company. Vanadium is a pale-gray metal with a silvery lustre. It is brittle, and has a crystalline structure. Its specific gravity is 6.02, and it melts at 3,236 deg. F. It does not oxidize in the air, and is not attacked by hydrochloric or dilute sulphuric acids. It dissolves with a blue color in solutions of nitric acid. It is marketed in lump forms in grades from 80 to 95 per cent pure. Vanadium readily alloys with iron. When added to steel in small quantities it toughens and deoxidizes it. It is used largely in special alloy steels, being added in the form of ferro-vanadium. The metal is also alloyed with copper. Vanadium salts are used to color pottery and glass, and as mordants in dyeing.

Vanadium steel. Vanadium is used in steel as a "scavenger" to insure sound steel, and enters into some alloy steels to the extent of 0.15 to 0.25 per cent. It also increases the tensile strength, without lowering the ductility. It reduces grain growth, and increases the fatigue-resisting qualities of steels. The steels, with 0.45 to 0.55 per cent of carbon, are used for locomotive forgings. Vanadium is also employed in special tool steels and in high-speed steel, increasing the work capacity of these steels for cutting metals, and giving a greater hardening range. Vanadium steels require higher quenching temperatures than ordinary steels or nickel steels. Vanadium steels containing about 0.15 per cent of vanadium, from 0.75 to 1.40 per cent of manganese, and from 0.40 to 0.75 per cent of carbon are

used for railroad rails. The tensile strength is about 125,000 lb. per sq. in. They have double the wear resistance of carbon-steel rails.

Varnish. A solution of a resin or drying oil, which when spread out in a thin film dries and hardens by evaporation of the volatile solvent, or by the oxidation of the oil, or both. A smooth, glossy coating is left on the surface. Varnishes do not contain pigments, and when mixed with pigments they become enamels. The most commonly used resin is ordinary rosin, and the most common drying oils are linseed and tung oils. Spirit varnishes are those in which a volatile liquid, such as alcohol or ether, is used as a solvent for the resin or oil. They dry by the evaporation of the solvent. Oleo-resinous varnishes are those in which the resin is compounded with an oxidizable oil, such as linseed oil. The gums used in varnish, such as copal, dammer, and kauri, produce hardness and gloss to the film. The oils, such as tung and linseed, make it elastic and durable. Other important ingredients of varnishes are driers, such as manganese oxide, to hasten the action of the drying oil, and thinning agents, or "reducers," such as turpentine, naphtha, and benzol. Hydrated lime is added to varnishes to neutralize the acid in the resin and to clarify and harden the varnish to prevent it from becoming sticky in warm weather. Spar varnishes are those made to withstand weather conditions. "Gloss oil" is a solution or rosin in benzine, and is of inferior grade. "Long" varnishes are those that contain more oil than the "short" varnishes, and they are more durable. Varnish is employed usually as a finish for fancy wood surfaces, but is also used as a protection against moisture on wood, paper, fiber, and other materials. See also Driers, Drying oils, Lacquer.

Vaseline. The name given in the pharmacy trade to highly refined petroleum jelly. It is a semi-solid yellowish substance, or nearly colorless when bleached with acids. See Petrolatum.

Vegetable ivory. The nut of a palm tree of tropical America, employed chiefly for making buttons and other small articles. See Ivory nut.

Vegetable oils. An important class of oils obtained from plants, and used industrially as drying oils, for lubricants, in cutting oils, for dressing leather, and for many other purposes. Many of the oils find wide usage in food products. Large tracts of land are under cultivation in all parts of the world for the production of the seeds and fruits from which the oils are obtained. Linseed, cottonseed, palm, olive, and castor beans are examples of these, and the oils are obtained by crushing. The only distinction between vegetable oils and fats is a physical one, oils being fluid at ordinary temperatures. Vegetable oils can be thickened for various uses by oxidation, by blowing air through them, or they can be hydrogenated by passing hydrogen through them in the presence of a catalyst. See Hydrogenated oils, Blown oils, Castor oil, Linseed oil, Cottonseed oil, Tung oil.

Velvet. A closely-woven silk fabric with a short pile on one side formed by carrying the warp threads over wires and then cutting open the loops. Velvet is made in a great variety of qualities and weights, and may have a cotton back in the cheaper grades, or be made in wool. True velvet is all silk, but because of the number of imitations in other materials this variety is usually designated as "silk velvet." Velvet is dyed in various colors, the depth of color shown by the pile giving it an air of richness. Its largest use is in dressgoods and hangings, but it is used industrially for upholstery, fancy lining, and trim.

Velveteen. A variety of imitation velvet, woven of cotton. In the best grades the pile is of mercerized yarns. Velveteen is woven with two systems of filling yarns and one system of warp yarns, the pile being made with the filling yarns instead of the warp yarns as in velvet. The ground

may be either plain or twill woven. Velveteen has a great variety of uses as a less expensive substitute for velvet.

Vermillion red. One of the oldest paint pigments. It is a brilliant red powder of the composition HgS, known chemically as red mercury sulphide. The specific gravity is about 8.10. It is insoluble in water. Vermillion red is expensive, and is consequently often adulterated with red lead, red ochre, or red iron oxide. It is made by heating mercury and sulphur. More than 85 per cent of its weight is mercury, and this accounts for its high cost.

Victor metal. A name given to a nickel-silver alloy containing 50 per cent of copper, 35 of zinc, and 15 of nickel. It casts well and machines easily, and is used for cast fittings. It is a white metal with a yellow shade. The alloy is very resistant to corrosion.

Vine black. The charred remains of partly burned vines or twigs, ground very fine and used as a pigment, especially for inks. The name is now also applied to the black made from fruit pits and nut shells.

Viscoloid. The trade name of a pyroxylin plastic molding material marketed by the Du Pont Viscoloid Company Arlington, N. J. It is used for molding various articles and is sold in sheets, rods, and tubes. See also Pyroxylin plastics.

Vitreosol. The trade name of a fused pure silica, or pure quartz, used for high-temperature and chemical-resistant crucibles, tubing, or furnace rods. It is a product of The Thermal Syndicate, Ltd., Brooklyn, N. Y. Vitreosol contains 99.8 per cent of SiO_2, and is marketed in three grades, according to transparency. It is entirely transparent to ultra-violet light. It can be furnished in tubes up to 3 in. in diameter, and in pots up to 50 gal. capacity or in any drawn shape.

Vitriol. The commercial name for sulphuric acid. It is also called oil of vitriol. See Sulphuric acid. "Green

vitriol" is the common name for ferrous sulphate. "Blue vitriol" is a name for copper sulphate. "White vitriol" is zinc sulphate.

Vulcabeston. An electric insulating material made of asbestos and rubber, the latter being used as a binder. It is a product of the Johns-Manville Company. It is grayish-brown in color, and will take a polish. It softens at about 175 deg. C., and can be molded into various shapes. It is fibrous, and not suitable for use in damp places. It has a transverse strength of 3,600 lb. per sq. in. An improved product is also made with a gum instead of rubber, with a softening temperature of about 275 deg. C., and a strength of 9,000 lb. per sq. inch.

Vulcanized fiber. A wood, paper, or other cellulose fiber-board impregnated with a gelatinizing medium. It is not vulcanized in the same sense that rubber is vulcanized. It is made by various processes, and the medium may be sulphuric acid, zinc chloride solution, or cupro-ammonium solution. It may also be made by impregnating the cellulose fiber with a phenol-furfural resin dissolved in alcohol or other solvent. After dipping in the solution the fiber is washed to remove excess alcohol, and then dipped in a zinc chloride solution which hydrolizes it, and it is then washed free of the chloride, dried, and rolled. Vulcanized fiber is used chiefly for electrical insulation. It has the disadvantage that it absorbs moisture, and is not suited for use in damp places.

Vulcanized rubber. Crude rubber, as obtained by precipitation or coagulation from the latex of the rubber tree, does not have the elastic or other properties of commercial rubber. To obtain these it is purified, and "vulcanized" by heating together with sulphur at a temperature of about 140 deg. C. From 3 to 35 per cent of sulphur is used, depending upon the class of rubber desired. A part of the sulphur is actually taken up by the molecule of the rubber, forming a chemical combination and not acting as a

filler. The ordinary soft, elastic rubbers contain from 3 t 5 per cent of sulphur. All rubber is vulcanized, but whe vulcanized rubber is designated in the trade it usually refer to the hard rubbers, or "Ebonite," made with about 30 pe cent of sulphur. These are very hard and brittle, and ar used for molded articles, especially for electrical parts "Ebonite" is now largely replaced by synthetic resins. Se Rubber.

Walnut. The wood of the tree *Juglans regia*, native t Europe. The wood is firm, with a fine to coarse, ope grain, and a lustrous surface. The weight is about 45 lb per cu. ft. The color is dark brown to black, and it takes beautiful polish. Walnut has great strength, toughness and elasticity. It also has great uniformity of texture, an does not split easily. It is particularly adapted for carving Walnut is valued as a cabinet wood, for fine furniture, an for gun stocks. Black walnut is from the tree *Juglan nigra*, of North America. The color is darker, and it has more uniform color than European walnut. It has th same general characteristics and uses as European walnu The American production of walnut in 1925 was 70,251,00 board feet. Walnut oil is a yellowish oil obtained by press ing the nut kernels. It is a good drying oil, and is use especially for artists' paints. The specific gravity is 0.91 to 0.929, and iodine value is 148. It is soluble in alcoho

Walrus hide. The skin of the walrus, a marine mamma *Odontobaenus rosmarus*, and *O. obesus*, native to the Nort Atlantic and Pacific Oceans. The animals sometimes hav a length of 16 ft., and a weight up to 2,000 lb., and the hid is therefore obtainable in large pieces. They congrega in herds on the icebergs of the North. The skin is tanne and makes a leather with a beautiful natural grain. It also very tough, and was formerly much used for coac traces. It is now employed where a tough and ornament leather is required. Walrus leather is imitated wi embossed sheepskin.

Wando steel. The trade name of a "non-shrinking" steel used for making dies and gages. It is an oil-hardening tool steel, and is a product of the Cyclops Steel Company, Titusville, Pa. Wando steel is hardened by quenching in oil from a temperature of about 1,450 deg. F. See Non-shrinking steel.

Warne's metal. An alloy of 10 parts of tin, 7 of nickel, 7 of bismuth, and 3 of cobalt. It is silvery-white in color and fine grained. It is employed as a substitute for silver in making ornamental articles.

Waste. The waste cotton threads and yarns from the cotton mills, used in manufacturing plants for wiping machinery. The best grades are usually all white, of clean soft threads without sizing or sweepings, and composed of yarns more than 10 in. long. Various other grades are available, composed of mixed white and colored threads, and the poorest having short threads and foreign matter. Good cotton waste is very absorbent, and makes a good wiping material in machine shops. It can be scoured and used over and over.

Water glass. A soluble silicate of sodium known chemically as sodium metasilicate, and having the composition $SiO_2 \cdot Na_2O$. When solid it is glassy in appearance, and dissolves in hot water. It melts at 1,018 deg. C. It is obtained by melting sodium carbonate with silica, or by melting sand, charcoal, and soda. The fused product is ground and dissolved in water by long boiling. A double-soluble glass is made by using both sodium and potassium carbonates. The latter alone makes a glass more soluble than sodium glass. Water glass is used as a protection for wood and porous stone, as a fixing agent for pigments, for cementing stoneware, waterproofing walls, greaseproofing paper containers, and for glazes. Mixed with whiting it is used as a strong cement for mounting cylindrical grinding wheels.

Water softeners. Chemical compounds used for con
verting the soluble scale-forming solids in boiler feed wate
into insoluble forms. In the latter condition they are the
removed by settling or filtration. The "hardness" o
water is due chiefly to the presence of carbonates, bicar
bonates, and sulphate of calcium and magnesium. Tem
porary hard waters are those that can be softened by boiling
and permanent hard waters are those that require chemical
to change their condition. Sodium hydroxide is used t
precipitate magnesium sulphate. Caustic lime is employe
to precipitate bicarbonate of magnesium, and sodiu
aluminate is used as an accelerator. Alum is used to precipi
tate mud and other impurities. Water softeners may con
sist of mixtures of lime, soda ash, and sodium aluminate
the three acting together very efficiently. Barium car
bonate may also be used as a softener. The water i
treated with the chemicals before it is run into the boile
See also Boiler compounds.

Wax. A general name for a great variety of substances o
animal and vegetable origin, which are esters of the fatt
acids, but differ from fats chiefly in the fact that glycerin i
not separated out on saponification. They are usuall
harder than fats, but when used alone do not mold as wel
The most familiar wax is beeswax, from the honey bee, bu
commercial beeswax is usually greatly mixed or adulterate
Vegetable waxes include Japan wax, candelilla, and carnaub
wax. Mineral waxes include paraffin wax from petroleu
ozokerite, ceresin, montan wax. Animal waxes are bee
wax, spermaceti, degras. Waxes are employed in polishe
phonograph records, leather dressings, sizings, water-proo
ing for paper, candles, and for many other uses. They a
usually of low melting point, are soluble in mineral spiri
and in alcohol, and insoluble in water.

Wax tailings. The distillate that comes from petroleu
after the wax-bearing distillate is removed. See Paraff
wax. Wax tailings contains no wax, but at ordina
temperatures looks like beeswax. It is very adhesive, a

is employed in the manufacture of roofings, and for waterproof coatings. It is shipped in tank cars, in which it is loaded at a temperature of 140 deg. F. A gallon of tailings at about 80 deg. F. weighs 9.18 pounds.

Weld. The dried plant, *Reseda luteola*, cultivated in Europe, and used as a dyestuff. The coloring matter in the plant is allied to morin, and produces an extremely bright yellow color with an alum mordant. With indigo it produces shades of green.

Western white cedar. The wood os the tree *Thuya gigantea*, also known under a variety of names such as yellow cedar, Canadian red cedar, red cedar, and arbor vitae. It is a soft wood with a brownish to reddish color, nearly white sap wood, and a pleasant odor. The grain is close but spongy. It is not strong, but is very durable when exposed to the weather. The weight is about 28 lb. per cu. ft. It is used for shingles, posts, boxes, and cabinet work. The tree is native to western United States and Canada. See also Port Orford cedar.

Whalebone. The elastic, horn-like strips in the upper jaw of the Greenland whale, *Balaena mysticetus*, and some other species. The strips are generally from 8 to 10 ft. long, and number about 600. Whalebone is light in weight, very flexible, elastic, tough, and durable. It is easily split, and is carved easily when softened in hot water. Whalebone has a great variety of uses in making whips and in articles that require flexibility. It is sometimes known under the name of baleen.

Whale oil. An oil extracted by boiling and steaming the blubber of several species of whale, *Balaena*, that are found chiefly in the cold waters of the extreme North and South. The whale industry now centers about South Georgia. Whale oil is marketed according to grade, which depends upon its color and keeping qualities. The latter in turn depends largely upon its proper cooking at extraction. No. 0 and No. 1 grades are fine pale-yellow oils, No. 2 is

amber, No. 3 is pale-brown, and No. 4 is the darkest oil The oils contain oleic, stearic, palmitic, and other acids The specific gravity is about 0.925, saponification valu 185, and iodine value 120. The oil of the sperm whal has a high content of spermaceti, and the iodine and saponi fication values are lower than whale oil. Whale oils o the lower grades are used for quenching baths for heat treating steels, and also in lubricating oils. The bes oils are hydrogenated for use in soaps and candles. Sperm oils are used for lubricating. See Sperm oil.

Whetstone. Stones of regular fine grains compose largely of chalcedony silica, often with minute garnet an rutile crystals. They are used as fine abrasive stone for the final sharpening of edge tools. The chocolate whetstone from New Hampshire is mica schist. The fines whetstones are termed oilstones. See Oilstone.

White acid. A name given to a mixture of hydrofluori acid with ammonium bifluoride, used for etching glass.

White brass. A bearing metal which is actually outsid of the range of the brasses, bronzes, or babbitt metals It is used in various grades, the specification adopted b the Society of Automotive Engineers being: Tin, 65 pe cent; zinc, 28 to 30 per cent; and copper, 3 to 6 per cent It is used for automobile bearings, and is close-grained hard, and tough. It also casts well. An entirely differen alloy is known under the name of white brass in the chea jewelry and novelty trade. It has no tin, small proportion of copper, and the remainder zinc. It is a high-zinc brass and varies in color from silvery-white to yellow dependin upon the copper content. "White nickel brass" is a grad of nickel silver.

White gold. The name of a class of jewelers' whit alloys used as substitutes for platinum. The name give no idea of the relative value of the different grades, whic vary widely. Gold and platinum may be alloyed togeth to make a white gold, but the usual alloys consist of fro

20 to 50 per cent of nickel, with the balance gold. Nickel and zinc with gold may also be used for white golds. The best commercial grades of white gold are made by melting the gold with a white alloy prepared for the purpose. This alloy contains nickel, silver, palladium, and zinc. The 14-carat white gold contains 14 parts of pure gold, and 6 of white alloy. A superior class of white gold is claimed to be made of 90 per cent of gold and 10 of palladium. "High-strength" white gold contains copper, nickel, and zinc, with the gold. Such an alloy, containing 37.5 per cent of gold, 28 of copper, 17.5 of nickel, and 17 of zinc, when "aged" by heat-treatment, has a tensile strength of about 100,000 lb. per sq. in., and an elongation of 35 per cent in 2 in. It is used for making jewelry, has a fine, white color, and is easily worked into intricate shapes.

White gunpowder. The name of a mixture in which the saltpeter of gunpowder is replaced by potassium chlorate. This powder explodes with great violence, but is very sensitive and extremely dangerous. It can be used only for percussion caps. Another mixture under the same name consists of 50 per cent of potassium chlorate, 25 per cent of potassium ferrocyanide, and 25 of sugar. It also is violently explosive and sensitive.

White lead. The common name of basic lead carbonate, an important paint pigment, and also used in putty. White lead is used in almost all mixed paints. It is a white, amorphous powder of the composition $2PbCO_3{\cdot}Pb(OH)_2$. It is insoluble in water, and decomposes on heating. It is marketed dry, or mixed with oils. It is sometimes adulterated with the ground mineral witherite, $BaCO_3$, or other compounds. White lead is a poison. Lead carbonate, $PbCO_3$, also is used as a pigment in the same way as the basic compound, but it discolors more easily. Basic lead sulphate, called "sublimed white lead," makes a fine white pigment. Commercial sublimed white lead contains 75 per cent of lead sulphate, 20 of lead oxide, and 5 of zinc

oxide. Commercial white lead may be mixed with litho-pone, magnesium oxide, antimony oxide, or other materials

Whitewood. A name sometimes given to the wood o the tulip tree, *Liriodendron tulipfera.* See Canary whitewood.

Whiting. Finely ground pure carbonate of lime, employed as a pigment for paints and inks, and for stamping and marking. It is also used for making putty. The composition is $CaCO_3$. See Chalk.

Widia metal. The trade name of an extremely hard composition made of tungsten carbide briquetted with a cobalt binder by diffusing the metal through the finely divided carbide under pressure. It is used for cutting tools for machining very hard metals or at very high speeds It is supplied in the form of small plates or blocks to be brazed on the end of the tools, and then ground to shape The name signifies "wie diamant," or like a diamond as the tungsten carbide is as high as 9.8 to 9.9 on the Moh hardness scale. Lathe and planer tools pointed with Widia metal are claimed to have more than ten times the cutting capacity of high-speed steels, and are not affected by high temperatures. They will also cut manganese steels and high-silicon irons. The metal has the disadvantage that it is not capable of withstanding shocks, and is likely to shatter if stopped suddenly in the cut. It is a product o the Friedrich Krupp Aktiengesellschaft, Essen, Germany.

Willemite. A valuable ore of the metal zinc. It i zinc ortho-silicate, Zn_2SiO_4, containing theoretically 58. per cent of zinc. Manganese often replaces part of th zinc, and it is then called troostite. Its structure is massiv or granular, and it has a vitreous luster. The color i white, yellowish-green, or blue when pure but with manga-nese it becomes apple-green, red, or brown. It may b transparent or opaque. The hardness is about 5.5, an the specific gravity is about 4. Willemite is found i various places in the United States and in Belgium.

Willow. The wood of the trees *Salix coerulea,* and *Salix alba,* native to Europe, but grown in many other places. It is best known as a material for cricket "bats" made in England. It is also employed for making artificial limbs, and articles where toughness and non-shrinking qualities are valued. The wood is brownish-yellow in color, has a fine, open grain, and weighs about 30 lb. per cu. ft. It is a soft-wood, of the approximate hardness of cherry and birch. Japanese willow is from the tree *Salix urbaniana.* It has a closer and finer texture, and has a browner color.

Wire cloth. Stiff fabrics made of fine wire woven with plain loose weave, and used for screens to protect windows, for guards, and for sieves and strainers. Steel and iron wire may be used, either plain, painted, galvanized, or rust-proofed, or various non-ferrous metal wires are employed. It is usually put up in rolls of 100 ft., in widths from 18 in. to 48 in. "Screen cloth" is usually 12, 14, 16 or 18 mesh, while "wire cloth" in copper, brass, or Monel metal is made regularly in meshes from 4 to 100. The size of wire usually varies from 0.009 to 0.065 in. in diameter.

Wire glass. A variety of glass extensively used in building construction for windows, doors, floors, and skylights, and having woven wire mesh imbedded in the center of the plate. It does not splinter or fly apart like common glass when subjected to fire or shock. It is made in standard thicknesses from ⅛ to ⅜ in., and in plates 60 by 110 in. and 61 by 140 in. Underwriters' specifications call for a minimum thickness of ¼ in. Wire glass is made with plain, rough, or polished surfaces, or with ribbed or cobweb surface on one side for diffusing the light and for decorative purposes. It is also obtainable in corrugated sheets. Wire glass ¼ in. thick weighs 2.25 lb. per sq. foot.

Wolframite. The chief ore of the metal tungsten. Its composition is $(FeMn)WO_4$. The ore is concentrated by gravity methods to a concentrate containing 60 to 65 per

cent of tungstic oxide, WO_3. To extract pure WO_3 from the concentrate it is fused with sodium carbonate, $NaCO_3$, to form sodium tungstate, $NaWO_3$, which is dissolved in water. When an acid is added to the solution the WO_3 precipitates out as a yellow powder. Wolframite occurs usually bladed or columnar in form. It has a specific gravity of 7.2 to 7.5, and a hardness of 5. It has a black color, and a sub-metallic luster. It is found in South Dakota, Colorado, Alaska, China, and Europe.

Wollaston wire. Any wire made by the Wollaston process of fine wire drawing. It consists in inserting a length of bare drawn wire into a close-fitting tube of another metal, the tube and core then being treated as a single rod and drawn through dies down to the required size. The outside jacket of metal is then dissolved away by an acid which does not affect the core metal. Platinum wire as fine as 0.00005 in. in diameter is made commercially by this method, and gold wire as fine as 0.00001 in. in diameter is also drawn. Wires of this fineness are employed only in instruments. They are marketed as composite wires, the user dissolving off the jacket.

Wood alcohol. The common name for methyl alcohol, formerly largely obtained from the distillation of wood. See Methyl alcohol.

Wood flour. Finely ground dried wood employed chiefly as a filler and reinforcing material in synthetic resins for molding work. It is made preferably from pine and spruce. Yellow pine is claimed to be superior as a raw material because of the high content of rosin. Woods containing essential oils, such as cedar, are not suitable. Ordinary sawdust can be converted into wood flour by grinding. Wood flour absorbs the resin as well as mixing with it, and makes a less brittle and tougher product for molded articles such as gears and handles. It also reduces the cost of the compound.

Wood's alloy. A "fusible alloy" having a low melting point, and used for fire extinguisher plugs, or for signal alarms. The melting point is about 160 deg. F., and it will melt in contact with hot water. The alloy contains 8 parts of lead, 4 of tin, 15 of bismuth, and 3 of cadmium. An alloy having a still lower melting point, about 140 deg. F., consists of 4 parts of bismuth, 2 of lead, 1 of tin, and 1 of cadmium. See Fusible alloys.

Wood turpentine. The oil of turpentine obtained from waste wood, chips, or sawdust by destructive distillation or by steam extraction. Wood turpentine forms more than 10 per cent of all American commercial turpentines. A percentage of pine oil and rosin is also obtained in the process. Wood turpentine has a peculiar characteristic saw-mill odor, and the residue of distillation has a camphor-like odor different from gum turpentine. It differs very little in composition, however, from the true turpentine. Some wood turpentine is also produced as a by-product in the manufacture of cellulose. Sulphite turpentine is a black oil obtained as a by-product in the manufacture of sulphite wood pulp from spruce. It collects on the surface of the liquid in the sulphur dioxide separator. It is purified with soda, and is used chiefly for making toluene and thymol. See also Turpentine.

Wool. The fine, soft, curly hair or fleece of the sheep, alpaca, vicuña, certain goats, and a few other animals. The specific designation wool always means the wool of sheep. Sheep's wool is one of the most important commercial fibers. It varies greatly in fineness and other qualities, depending largely upon the breed of sheep. The spinning and weaving of wool antidates written history. Wool differs from hair in fineness and in its felting properties. The latter is due to the fine scales on the wool fibers. These scales vary from 1,000 to 3,000 to the inch, but are not found on ordinary hair. They give to the wool the cohesive qualities. Some animals have both wool and hair, while

others have wool only when very young. There is no sharp dividing line between wool and hair. The finest of the sheep wools come from the Merino sheep, but these vary according to the age and breeding of the animal. The Lincoln sheep produces the longest fiber. It is lustrous, but very coarse. Wool is shipped in bales of 200 kilograms. The chief producing countries are Australia, Argentina, and Russia.

Wrought iron. The commercially pure iron resulting from the reduction of the carbon in cast iron, and employed for construction and tank plates. It is obtained by melting white cast iron, and passing an oxidizing flame over it. The iron is left in a pasty condition full of holes, and is then rolled or hammered to unite it into one mass. Wrought iron is a series of welds, and usually bears slag. It is therefore not suitable for important parts requiring strength. The quality grades of wrought iron refer to the amount of working which the metal has received. When the word iron is used alone it generally refers to wrought iron. Iron may be case-hardened by rubbing the surface with potassium cyanide or other carbonizing agent when at a red heat, and then quenching in water. The tensile strength of wrought iron varies from 41,000 to 56,000 lb. per sq. in. If 0.35 per cent or more of silicon is present the iron is "cold short," and will also be difficult to weld. The carbon content of wrought iron should be under 0.08 per cent. Wrought iron is now largely replaced by ingot iron or steels containing only slight percentages of carbon because of the greater uniformity, and freedom from slag and cracks. See also Ingot iron, and Electrolytic iron.

Wulfenite. An ore of the metal molybdenum. It is a lead molybdate, $PbMoO_4$, and occurs in lead veins with other ores of lead. It is found in Utah, Nevada, Arizona, and New Mexico. Wulfenite occurs in crystals, and also massive granular. The specific gravity is 6.05, and the hardness is 4.5. Its color is yellow, orange, gray, red, or white.

Xylonite. A name sometimes applied to celluloid, but originally a nitro-cellulose product invented by Spill in 1868. It originally consisted of 40 parts of nitro-cellulose, 20 parts of camphor, and 40 parts of linseed or castor oil. Later patents were obtained by the same inventor for gelatinizing the nitro-cellulose with a solution of camphor in ethyl alcohol. See Celluloid. Xylonite is at present the trade name of a pyroxylin plastic molding material marketed by the British Xylonite Company, Ltd.

Xylyl bromide. A lachramatory gas used in chemical warfare. It is made by the action of bromine on xylene in sunlight, and has a composition of $CH_3{\cdot}C_6H_4{\cdot}CH_2Br$. It is a colorless liquid with a specific gravity of 1.371 and boiling point at about 216 deg. C. It is employed in high-explosive shells, and the disseminated mist causes a copious flow of tears.

Y alloy. A light-weight alloy developed in England. It contains about 4 per cent of copper, 2 of nickel, 1.5 of magnesium, and the balance aluminum. By quenching the hot-rolled alloy at 520 deg. C., a tensile strength of 54,000 lb. per sq. in. has been developed. It is resistant to alternating stresses even at elevated temperatures. It is also claimed to be very resistant to the action of sea water. The Y alloy employed by one of the largest airplane engine builders contains 3.5 to 4.75 per cent of copper, 1.75 to 2.25 of nickel, 1.25 to 1.75 of magnesium, a maximum of 0.75 of iron, a maximum of 0.50 of silicon, and the balance aluminum. The untreated castings have a tensile strength of 24,000 lb. per sq. in., and a Brinell hardness of 80. When quenched from 950 deg. F., and aged at 450 deg. F. they have a hardness of 95, and a tensile strength of 30,000 lb. per sq. inch.

Yellow birch. The common name for the wood of the tree *Betula lutea*, of the northeastern states of the United States. The lumber is generally classified with that of other species of birch. See Birch.

Yellow casting brass. The commercial name of a brass capable of making clean, dense castings, and used for the general casting of machine parts except bearings. The composition used by the General Motors Corporation is 63.5 per cent of copper, 33.5 per cent of zinc, and 3 per cent of lead. The ultimate strength is 25,000 lb. per sq. in., and the elongation is 20 per cent in 2 in. Another brass giving excellent, clear, dense, and tough castings is made from 85 per cent of copper, 5 of tin, 5 of lead, and 5 of zinc. It is poured at from 1,600 to 1,800 deg. F. This mixture is in reality a bronze.

Yellow cedar. The wood of the tree *Chamaecyparis mitkaensis*, or *Cupressus mitkaensis*, of the United States and Canada. It has a light yellowish-red color, with a handsome streaked grain. The weight is about 30 lb. per cu. ft. It is very durable. It is employed for boxes, shingles, posts, and in boat building. The wood is also called yellow cypress, and Alaska cedar. See also Port Orford cedar.

Ytterbium. A metallic element, symbol Yb, belonging to the rare earth group. It was discovered in the mineral gadolinite in 1878. It has not as yet been separated, and is obtained only in the form of its salts.

Yttrium. A metallic element, symbol Yt, found in the mineral gadolinite with other rare earths. Metallic yttrium is obtained only with great difficulty. It is a dark-gray powder, having a specific gravity of 3.80, and melting at 1,250 deg. C. It decomposes water, and is dissolved in most mineral acids. It is not as yet employed commercially.

Zinc. A bluish-white metal, symbol Zn. When cast into slabs in the impure form it is often called spelter in the trade. It is obtained chiefly from the minerals sphalerite and calamine. The United States produces nearly half of the world's production of more than 1,000,000 tons of the metal annually. Zinc is hard and brittle, and has a highly crystalline structure when broken. It melts at

787 deg. F., and boils at 1,706 deg. F. The specific gravity is 7.142. At about 300 deg. F. it is ductile, and can be rolled into thin sheets. Zinc casts readily. On exposure to the air the metal becomes coated with a film of carbonate, and is then very resistant to corrosion. Zinc is employed for galvanizing iron and steel, and in electric batteries. It is an important metal for alloying with copper in making brasses. Zinc dust and zinc oxide are used for paint making. The highest grades of commercial zinc are 99.9 per cent pure. "Sterling spelter" is 99.5 per cent zinc, with a little cadmium, lead, and iron as impurities. Zinc for brass making does not contain more than 0.60 per cent of lead, and 0.03 per cent of iron. The Grade D, or "Prime western," zinc contains 98 per cent of zinc. It is the grade used in galvanizing. Zinc comes in slabs of about 50 lb. each. Forty-one per cent of the American consumption of zinc is for galvanizing, 31 per cent for brass, and 12 for sheet zinc.

Zinc chromate. Also called zinc yellow, and buttercup yellow. A beautiful, stable, yellow pigment, coming in various tints, and used in paints. It is a crystalline powder of the composition $ZnCrO_4$, and specific gravity of 3.5. It is made by adding a hot neutral solution of zinc sulphate to potassium chromate. It does not have the covering power of chrome yellow, but it has the advantage that it does not blacken by exposure to sulphides. It is used largely for mixing with Prussian blue to form greens.

Zincite. An ore of the metal zinc, but used chiefly for the production of the zinc oxide known as zinc white employed as a pigment. Zincite has a composition of ZnO, containing theoretically 80.3 per cent of zinc. The mineral has usually a massive granular structure with a deep-red to orange streaked color. It may be translucent or almost opaque. It is found and worked in New Jersey.

Zinc powder. Also known as zinc dust. A specially distilled fine metallic zinc powder used in paints for the protection of iron and steel against corrosion. An impor-

tant use, also, is for coating metals by the sheardizing process. It is usually made up with boiled or raw linseed oil, turpentine, and a drier such as manganese resinate. It may also be mixed with 10 to 25 per cent of zinc oxide, to aid in keeping the dust in suspension, to harden the film, and to brighten the color. Zinc powder is a condensed zinc vapor, or an atomized zinc, and is of such fineness that 90 to 95 per cent should pass through a 325-mesh screen. Zinc powder is easily wetted by oils or lacquers, and does not have to be ground in a paint mill. The paints made with the powder are claimed to be very resistant to weathering, and are used for structural and factory painting.

Zinc white. The oxide of zinc, ZnO, used as a paint pigment, and also as a filler in rubber. It is made directly from the ore, the mineral zincite, by reducing it in a special furnace with coal and an excess of air. It is also made from metallic zinc by vaporizing and burning the zinc in the air. Zinc white is a white powder, having a specific gravity of 5.78. It is insoluble in water. More than 100,000 tons of zinc white are used annually in the United States. "Leaded zinc oxide" is a pigment consisting of zinc oxide and basic lead sulphate. It may contain from 3 to 25 per cent of lead. Zinc white paste should contain 90 per cent of the pigment, and 10 of linseed oil. Another white zinc compound, used for flatting paints, is zinc stearate. It has the composition $Zn(C_{18}H_{35}O_2)_2$, and is a white, agglutinating powder.

Zirconia. The oxide of the metal zirconium, having the composition ZrO_2. Its chief source is by reduction from the mineral baddeleyite, which contains an average of 84 per cent of zirconia. The melting point of zirconia is about 3,000 deg. C. when pure, and it is used as a refractory material, and in some quartz ware. By heating zirconia with carbon a zirconium carbide is formed which is a very hard abrasive. Zirconia is also the chief source of the metal zirconium. When zirconia is used as a refractory, lime or other material is used as a binder, which lowers the melting point of the refractory. Vessels made of zirconia can

be plunged white hot into cold water without fracturing them. Its coefficient of expansion is also very low, 0.00000084. It is sometimes used for furnace linings, and is more refractory than silica. Zirconia is a white, amorphous powder having a specific gravity of 5.0. It is soluble in nitric acid.

Zirconium. An elementary metal, symbol Zr, silvery-white in color, and having a specific gravity of 6.4. Its melting point is about 3,000 deg. F., and it has a Scleroscope hardness of 40 to 45. Zirconium always occurs in combined form, chiefly in the minerals zircon and baddeleyite. It is very difficult to reduce to metallic form as it readily combines with oxygen, nitrogen, carbon, and silicon. Its production is therefore expensive. The metal is not attacked by nitric or sulphuric acids, but is dissolved by hydrofluoric acid. It has been alloyed with nickel for cutting tools, and in copper alloys. See Cooperite. It does not make copper sluggish as does titanium, and bronze containing zirconium can be poured freely. Zirconium is also added to steel, and has a powerful deoxidizing action, producing a steel with uniformity of grain. It also combines with the sulphur and reduces hot-shortness in the steel, and also carries off the nitrogen, making a more ductile steel.

Zirconium-ferrosilicon. An alloy of zirconium with iron and silicon, employed for adding zirconium to steel and to special irons. A typical analysis of the product, as given by the Electro Metallurgical Sales Corporation, is: 9 to 12 per cent of zirconium, 40 to 47 per cent of silicon, 40 to 45 of iron, and a maximum of 0.20 per cent of carbon. Zirconium deoxidizes the steel, carries off much of the sulphur and nitrogen, and makes a more uniform steel capable of withstanding shocks. When it is desired to add considerable amounts of zirconium without an excessive increase of silicon, a "silicon-zirconium" alloy, containing higher percentages of zirconium, is used. These alloys contain from 35 to 40 per cent of zirconium, and about 50 per cent of silicon, with less than 10 per cent of iron.

APPENDIX I

UNITS OF MEASURE

Unless specifically noted, the units used in this book are as follows: Ton, is the long ton of 2,240 pounds; the pound is the avoirdupois pound of 16 ounces, or 7,000 grains; the gallon is the United States gallon of 231 cubic inches.

For vessel, or shipping, capacity the terms "gross" and "net" tonnage refer to space measurement of 100 cubic feet to the ton. Gross tonnage is the capacity of the entire space within the frames and ceiling of the hull, plus the available closed-in spaces above deck. Net, or registered, tonnage is what remains after deducting from the gross tonnage the spaces occupied by machinery, fuel, and quarters, and represents actual space available for freight-cargo and passengers.

Useful Conversion Factors

1 pound = 0.4536 kilograms
1 kilogram = 2.207 pounds
1 gram = 15.43 grains = 0.03572 avoir. ounce
1 metric ton = 1,000 kilograms = 0.9842 long ton = 1.102 short tons
1 troy ounce = 31.1 grams
1 avoirdupois ounce = 28.35 grams
1 metric carat = 0.200 gram
1 square meter = 1.196 sq. yd.
1 liter = 1.057 liquid quarts

1 bushel = 2,150.4 cu. in.
1 gallon = 231 cu. in.
1 cubic foot = 1,728 cu. in.
Specific gravity × 0.036 = weight in lb. per cu. in.
1 troy pound = 12 ounces
1 carat = 0.205 gram
1 board foot = 144 cu. in.
1 barrel (oils) = 42 gallons

Foreign Units

1 hundred weight (British) = 112 lb.
1 quintal (British Empire) = 112 lb.
1 metric quintal = 100 kilograms = 220.5 lb.
1 imperial bushel (British) = 1.0315 United States' bu.
1 imperial gallon (British) = 1.20 United States' gallon
1 proof gallon (British) = 1.37 United States' proof gal.
1 Ionian pound (Greece) = 1 avoirdupois lb.
1 Venetian pound = 1.058 lb.
1 pood (Russian) = 36.11 lb.
1 arshin (Russian) = 28 in.
1 vedro (Russian) = 3.249 gal.
1 picul (China) = 100 catties = 133⅓ lb.
1 picul (East Indies) = 136.2 lb.
1 picul (Japan) = 132.3 lb.
1 koku (Japan) = 47.65 gal. = 5.119 bu.
1 kwan (Japan) = 1,000 momme = 8.267 lb.

Metric Length Measurements

Unit	Inches	Feet	Millimeters	Centimeters	Meters
One inch	1.	0.0833	25.4	2.54	0.025
One foot	12.	1.	304.8	30.48	0.304
One millimeter	0.03937	0.00328	1.	0.1	0.001
One centimeter	0.3937	0.0328	10.	1.	0.01
One meter	39.37	3.2809	1000.	100.	1.
One yard	36.	3.	914.4	91.44	0.914

Temperature Conversion Scale

To change a temperature in degrees Centigrade, to degrees Fahrenheit, multiply by $\frac{9}{5}$ and add 32, thus, $F = \frac{9}{5}(C + 32)$. To change degrees Fahrenheit, to degrees Centigrade, subtract 32 and multiply by $\frac{5}{9}$, thus $C = \frac{5}{9}(F - 32)$.

C.	F.	C.	F.	C.	F.	C.	F.	C.	F.
0	32	230	446	460	860	690	1274	920	1688
5	41	235	455	465	869	695	1283	925	1697
10	50	240	464	470	878	700	1292	930	1706
15	59	245	473	475	887	705	1301	935	1715
20	68	250	482	480	896	710	1310	940	1724
25	77	255	491	485	905	715	1319	945	1733
30	86	260	500	490	914	720	1328	950	1742
35	95	265	509	495	923	725	1337	955	1751
40	104	270	518	500	932	730	1346	960	1760
45	113	275	527	505	941	735	1355	965	1769
50	122	280	536	510	950	740	1364	970	1778
55	131	285	545	515	959	745	1373	975	1787
60	140	290	554	520	968	750	1382	980	1796
65	149	295	563	525	977	755	1391	985	1805
70	158	300	572	530	986	760	1400	990	1814
75	167	305	581	535	995	765	1409	995	1823
80	176	310	590	540	1004	770	1418	1000	1832
85	185	315	599	545	1013	775	1427	1005	1841
90	194	320	608	550	1022	780	1436	1010	1850
95	203	325	617	555	1031	785	1445	1015	1859
100	212	330	626	560	1040	790	1454	1020	1868
105	221	335	635	565	1049	795	1463	1025	1877
110	230	340	644	570	1058	800	1472	1030	1886
115	239	345	653	575	1067	805	1481	1035	1895
120	248	350	662	580	1076	810	1490	1040	1904
125	257	355	671	585	1085	815	1499	1045	1913
130	266	360	680	590	1094	820	1508	1050	1922
135	275	365	689	595	1103	825	1517	1055	1931
140	284	370	698	600	1112	830	1526	1060	1950
145	293	375	707	605	1121	835	1535	1065	1949
150	302	380	716	610	1130	840	1544	1070	1958
155	311	385	725	615	1139	845	1553	1075	1967
160	320	390	734	620	1148	850	1562	1080	1976
165	329	395	743	625	1157	855	1571	1085	1985
170	338	400	752	630	1166	860	1580	1090	1994
175	347	405	761	635	1175	865	1589	1095	2003
180	356	410	770	640	1184	870	1598	1100	2012
185	365	415	779	645	1193	875	1607	1105	2021
190	374	420	788	650	1202	880	1616	1110	2030
195	383	425	797	655	1211	885	1625	1115	2039
200	392	430	806	660	1220	890	1634	1120	2048
205	401	435	815	665	1229	895	1643	1125	2057
210	410	440	824	670	1238	900	1652	1130	2066
215	419	445	833	675	1247	905	1661	1135	2075
220	428	450	842	680	1256	910	1670	1140	2084
225	437	455	851	685	1265	915	1679	1145	2093

Metal Gages in Common Use

Gage No.	B. & S.	B.W. G.	B.I. G.	W.& M.	Music wire	U. S. G.	Twist drill	Stubs steel wire	Amer. screw	Zinc
7-0	.....	.....	.500	.4900	.....	.5000	.....	.....	.....	.....
6-0	.....	.....	.464	.4600	.....	.4690	.....	.....	.....	.....
5-0	.....	.....	.432	.4300	.....	.4380	.....	.....	.....	.....
4-0	.4600	.454	.400	.3940	.....	.4060	.....	.....	.....	.....
3-0	.4100	.425	.372	.3630	.....	.3750	.....	.....	.0315	.....
2-0	.3650	.380	.348	.3310	.0085	.3440	.....	.....	.0447	.....
0	.3250	.340	.324	.3070	.0090	.3130	.....	.....	.0578	.....
1	.2890	.300	.300	.2830	.0100	.2810	.2280	.227	.0710	.002
2	.2580	.284	.276	.2630	.0110	.2660	.2210	.219	.0842	.004
3	.2290	.259	.252	.2440	.0120	.2500	.2130	.212	.0973	.006
4	.2040	.238	.232	.2250	.0130	.2340	.2090	.207	.1100	.008
5	.1820	.220	.212	.2070	.0140	.2190	.2055	.204	.1240	.010
6	.1620	.203	.192	.1920	.0160	.2030	.2040	.201	.1370	.012
7	.1440	.180	.176	.1770	.0180	.1880	.2010	.199	.1500	.014
8	.1290	.165	.160	.1620	.0200	.1720	.1990	.197	.1630	.016
9	.1140	.148	.144	.1480	.0220	.1560	.1960	.194	.1760	.018
10	.1020	.134	.128	.1350	.0240	.1410	.1940	.191	.1890	.020
11	.0907	.120	.116	.1210	.0260	.1250	.1910	.188	.2030	.024
12	.0808	.109	.104	.1060	.0280	.1090	.1890	.185	.2160	.028
13	.0720	.095	.092	.0915	.0300	.0938	.1850	.182	.2290	.032
14	.0641	.083	.080	.0800	.0320	.0781	.1820	.180	.2420	.036
15	.0571	.072	.072	.0720	.0340	.0703	.1800	.178	.2550	.040
16	.0508	.065	.064	.0625	.0360	.0625	.1770	.175	.2680	.045
17	.0453	.058	.056	.0540	.0380	.0563	.1730	.172	.2820	.050
18	.0403	.049	.048	.0475	.0400	.0500	.1695	.168	.2950	.055
19	.0359	.042	.040	.0410	.0420	.0438	.1660	.164	.3080	.060
20	.0320	.035	.036	.0348	.0440	.0375	.1610	.161	.3210	.070
21	.0285	.032	.032	.0318	.0460	.0344	.1590	.157	.3340	.080
22	.0254	.028	.028	.0286	.0480	.0313	.1570	.155	.3470	.090
23	.0226	.025	.024	.0258	.0510	.0281	.1540	.153	.3610	.100
24	.0201	.022	.022	.0230	.0550	.0250	.1520	.151	.3740	.125
25	.0179	.020	.020	.0204	.0590	.0219	.1500	.148	.3870	.250
26	.0159	.018	.018	.0181	.0630	.0188	.1470	.146	.4000	.375
27	.0142	.016	.0164	.0173	.0670	.0172	.1440	.143	.4130	.500
28	.0126	.014	.0148	.0162	.0710	.0156	.1410	.139	.4260	1.000
29	.0113	.013	.0136	.0150	.0740	.0141	.1360	.134	.4390	.....
30	.0100	.012	.0124	.0140	.0780	.0125	.1285	.127	.4530	.....
31	.0089	.010	.0116	.0132	.0820	.0109	.1200	.120	.4660	.....
32	.0079	.009	.0108	.0128	.0860	.0101	.1150	.115	.4790	.....
33	.0071	.008	.0100	.0118	.0900	.0094	.1130	.112	.4920	.....
34	.0063	.007	.0092	.0104	.0940	.0086	.1110	.110	.5050	.....
35	.0056	.005	.0084	.0095	.0980	.0078	.1100	.108	.5180	.....
36	.0050	.004	.0076	.0090	.1020	.0070	.1065	.106	.5320	.....
37	.0044	.....	.0068	.0085	.1060	.0066	.1040	.103	.5450	.....
38	.0040	.....	.0060	.0080	.1120	.0063	.1015	.101	.5580	.....
39	.0035		.0052	.0075	.1180	.....	.0995	.099	.5710	.....
40	.0031	.....	.0048	.0070	.1250	.....	.0980	.097	.5840	.....

METAL GAGES IN COMMON USE (*Continued*)

Gage No.	B. & S.	B.W. G.	B.I. G.	W. & M.	Music wire	U. S. G.	Twist drill	Stubs steel wire	Amer. screw	Zinc
41	.....	.....	.0044	.0066	.....	.....	.0960	.095	.597	
42	.....	.....	.0040	.0062	.....	.....	.0935	.092	.611	
43	.....	.....	.0036	.0060	.....	.....	.0890	.088	.624	
44	.....	.....	.0032	.0058	.....	.....	.0860	.085	.637	
45	.....	.....	.0028	.0055	.....	.....	.0820	.081	.650	
46	.....	.....	.0024	.0052	.....	.....	.0810	.079	.663	
47	.....	.....	.0020	.0050	.....	.....	.0785	.077	.676	
48	.....	.....	.0016	.0048	.....	.....	.0760	.075	.690	
49	.....	.....	.0012	.0046	.....	.....	.0730	.072	.703	
50	.....	.....	.0010	.0044	.....	.....	.0700	.069	.716	
51	.....	.....	.....	.....	.....	.....	.0670			
52	.....	.....	.....	.....	.....	.....	.0635			
53	.....	.....	.....	.....	.....	.....	.0595			
54	.....	.....	.....	.....	.....	.....	.0550			
55	.....	.....	.....	.....	.....	.....	.0520			
56	.....	.....	.....	.....	.....	.....	.0465			
57	.....	.....	.....	.....	.....	.....	.0430			
58	.....	.....	.....	.....	.....	.....	.0420			
59	.....	.....	.....	.....	.....	.....	.0410			
60	.....	.....	.....	.....	.....	.....	.0400			

The Brown & Sharpe, or American standard, wire gage is used for aluminum, brass, bronze, and German silver sheet, also for non-ferrous wires and rod.

The Birmingham wire gage (B.W.G.), also known as the Stubs' iron wire gage, applies to seamless tubing and to sheet spring steel.

The British imperial gage (B.I.G.), also known as the legal standard gage (L.S.G.), is used in Great Britain, and sometimes in the United States for copper wire.

The Washburn & Moen gage, also known as the Roebling gage, or the national wire gage, applies to all bare, galvanized, and annealed steel and iron wire, and to tinned steel wire, and spring steel wire.

The music wire gage is used for "music" wire.

The United States standard gage is used for steel and iron plate, galvanized, tinned, or terne.

The twist drill gage, also known as the Morse gage, is used for drill steel rod.

Stubs' steel wire gage is used for steel drill rod.

The American screw gage is applied to machine screws.

The zinc gage is used for sheet zinc.

Hardness Numbers

The Brinell method of determining hardness is by the indentation effect of a hard ball pressed into the surface of the metal to be tested. Tables of hardness numbers corresponding to the various identation measurements are furnished by the makers of the machines.

The Scleroscope, or "Shore," method measures hardness by a comparison of the effect of the drop and rebound of a diamond-tipped hammer dropping by gravity from a fixed height. The resulting rebound is then read on a graduated scale.

The Rockwell hardness tester measures hardness by determining the depth of penetration under load of a steel ball or diamond cone in the material being tested. Rockwell hardness is expressed as a number, which is read on a graduated gage.

The Moh hardness scale for abrasives and minerals is measured by scratch comparison, the mineral talc being taken as 1, and the diamond as 10 on the scale.

Scale of Hardness for Minerals—Moh Scale

	Hardness Number		Hardness Number
Talc	1	Orthoclase	6
Gypsum	2	Quartz	7
Calcite	3	Topaz	8
Fluorite	4	Corundum	9
Apatite	5	Diamond	10

Hardness Grades in Woods

1. Excessively hard	Lignum-vitae, Ebony
2. Extremely hard	Boxwood, Lilac, Jarrah, Karri, Bluegum
3. Very hard	Whitehorn, Blackthorn, Persimmon
4. Hard	Hornbeam, Elder, Yew, Laburnum
5. Rather hard	Ash, Holly, Plum, Elm
6. Firm	Teak, Chestnut, Beech, Walnut, Apple, Oak
7. Soft	Willow, Deal, Alder, Australian Red cedar, Birch, Hazel
8. Very soft	White pine, Poplar, Redwood.

THE ELEMENTS

Name	Symbol	Atomic weight H = 1	Melting point Deg. C.	Melting point Deg. F.
Aluminum	Al	27.1	658.7	1217.7
Antimony	Sb	120.2	630.0	1166
Argon	A	39.88	−188	−306
Arsenic	As	74.96	850?	1562
Barium	Ba	137.37	850	1562
Beryllium	Be	9.1	1350	2462
Bismuth	Bi	208.0	271	520
Boron	B	11.0	2200–2500	4000–4500
Bromine	Br	79.92	−7.3	+18.9
Cadmium	Cd	112.40	320.9	609.6
Caesium	Cs	132.81	−26	79
Calcium	Ca	40.07	810	1490
Carbon	C	12.00	3600	6500
Cerium	Ce	140.25	640	1184
Chlorine	Cl	35.46	−101.5	−150.7
Chromium	Cr	52.0	1520	2768
Cobalt	Co	58.97	1480	2696
Columbium	Cb	93.5	1700?	3090
Copper	Cu	63.57	1083.0	1981.5
Dysprosium	Dy	162.5	....	....
Erbium	Er	167.7	....	....
Europium	Eu	152.0	....	....
Fluorine	F	19.0	−223	−369
Gadolinium	Gd	157.3	....	....
Gallium	Ga	69.9	30	86
Germanium	Ge	72.5	958	1756
Gold	Au	197.2	1063.0	1945.5
Helium	He	3.99	271	456
Holmium	Ho	163.5	....	....
Hydrogen	H	1.008	−259	−434
Indium	In	114.8	155	311
Iodine	I	126.92	113.5	236.3
Iridium	Ir	193.1	2350	4262
Iron	Fe	55.84	1530	2786
Krypton	Kr	82.92	−169	−272
Lanthanum	La	139.0	810?	1490
Lead	Pb	207.10	327.4	621.8
Lithium	Li	6.94	186	367
Lutecium	Lu	174.0	....	....
Magnesium	Mg	24.32	651	1204
Manganese	Mn	54.93	1260	2300
Mercury	Hg	200.6	−38.9	−38
Molybdenum	Mo	96.0	2500	4500

Name	Symbol	Atomic weight H = 1	Melting point Deg. C.	Melting point Deg. F.
Neodymium	Nd	144.3	840	1544
Neon	Ne	20.2	−253	−423
Nickel	Ni	58.68	1452	2646
Nitron {Radium Emanation	Nt.	222.4	....	....
Nitrogen	N	14.01	−210	−346
Osmium	Os	190.9	2700	4900
Oxygen	O	16.00	−218	−360
Palladium	Pd	106.7	1549	2820
Phosphorus	P	31.04	44	111.2
Platinum	Pt	195.2	1755	3191
Potassium	K	39.10	62.3	144
Praseodymium	Pr	140.6	940?	1724
Radium	Ra	226.4	700	1292
Rhodium	Rh	102.9	1950	3542
Rubidium	Rb	85.45	38	100
Ruthenium	Ru	101.7	2450	4442
Samarium	Sa	150.4	1300 1400	2370 2550
Scandium	Sc	44.1		....
Selenium	Se	79.2	217 220	422 428
Silicon	Si	28.3	1420	2588
Silver	Ag	107.88	960.5	1761
Sodium	Na	23.00	97.5	207.5
Strontium	Sr	87.63	....	....
Sulphur	S	32.07	112.8 119.2 106.8	235.0 246.6 224.2
Tantalum	Ta	181.5	2850	5160
Tellurium	Te	127.5	452	846
Terbium	Tb	159.2	....	....
Thallium	Tl	204.0	302	376
Thorium	Th	232.4	1700 Pt.	3090 Pt.
Thulium	Tm	168.5	....	....
Tin	Sn	119.0	231.9	449.4
Titanium	Ti	48.1	1800	3272
Tungsten	W	184.0	3350	6062
Uranium	U	238.5	1850	3362
Vanadium	V	51.0	1720	3128
Xenon	Xe	130.2	−140	−220
Ytterbium	Yb	172	....	....
Yttrium	Yt	89.0	1490	2714
Zinc	Zn	65.37	419.4	786.9
Zirconium	Zr	90.6	1700	3090

The Electro-chemical Series of Elements

In the table given below, the elements are electro-positive to the ones which follow them, and will displace them from solutions of their salts.

1 Caesium	23 Nickel	45 Silicon
2 Rubidium	24 Cobalt	46 Titanium
3 Potassium	25 Thallium	47 Columbium
4 Sodium	26 Cadmium	48 Tantalum
5 Lithium	27 Lead	49 Tellurium
6 Barium	28 Germanium	50 Antimony
7 Strontium	29 Indium	51 Carbon
8 Calcium	30 Gallium	52 Boron
9 Magnesium	31 Bismuth	53 Tungsten
10 Beryllium	32 Uranium	54 Molybdenum
11 Ytterbium	33 Copper	55 Vanadium
12 Erbium	34 Silver	56 Chromium
13 Scandium	35 Mercury	57 Arsenic
14 Aluminum	36 Palladium	58 Phosphorus
15 Zirconium	37 Ruthenium	59 Selenium
16 Thorium	38 Rhodium	60 Iodine
17 Cerium	39 Platinum	61 Bromine
18 Didymium	40 Iridium	62 Chlorine
19 Lanthanum	41 Osmium	63 Fluorine
20 Manganese	42 Gold	64 Nitrogen
21 Zinc	43 Hydrogen	65 Sulphur
22 Iron	44 Tin	66 Oxygen

APPENDIX II

STANDARD CLASSIFICATIONS FOR MARKETING IRON AND STEEL SCRAP

(Adopted by the Bureau of Standards)

Cast Iron

Cast-Iron Borings. Clean cast-iron borings, free from badly corroded material, lumps, scale, other metals, dirt, or foreign material of any kind. This material is for use in blast furnaces.

Burnt Iron Scrap. Old annealing boxes, tools and pots, grate bars, and similar burnt iron. No dimensions should exceed 9 in., except brake shoes which may be included. This material is used for the blast furnace or gray-iron foundry.

No. 1 Cast-Iron Scrap. Contains all kinds of machinery and similar cast-iron scrap. Nothing under 10 lb. nor over 500 lb. in weight, nor over 48 in. long and 18 in. wide. It should contain no brake shoes, cast-iron soil or water pipe, stove scrap nor burnt iron of any description, and should be free from steel parts. It is used for the basic open-hearth furnace.

No. 2 Cast-Iron Scrap. Contains all kinds of agricultural implements of cast iron free from steel parts. Nothing under 10 lb. nor over 500 lb. in weight, nor over 48 in. long by 18 in. wide. It must contain no stove scrap nor burnt iron of any description. It is used for the basic open-hearth furnace.

No. 3 Cast-Iron Scrap. Consists of cast-iron scrap with steel parts attached. Nothing under 10 lb. nor over

500 lb. in weight, nor over 48 in. long by 18 in. wide. It is used for the basic open-hearth furnace.

Heavy Breakable Cast Scrap. Heavy cast iron, suitable for breaking under the buyer's drop hammer. Pieces are not to exceed 10 tons in weight. It should be free from anvil blocks, hammer bases, and like material. It should contain no burnt iron. This material is used in the basic open-hearth furnace.

No. 1 Machinery Breakable Scrap. Clean machinery cast-iron scrap weighing over 150 lb., which can be broken easily by an ordinary drop into cupola size. It is used for the gray-iron foundry.

No. 1 Machinery Cupola Scrap. Clean machinery cast-iron scrap which must be of cupola size, not over 24×30 in. dimensions, and no piece to weigh over 150 pounds.

No. 1 Standard Cupola Scrap. All clean cast-iron scrap, such as columns, pipe, plates, and castings of miscellaneous nature, free from stove plate and agricultural scrap. It must be of cupola size, not over 24×30 in. in dimensions, and no piece to weigh over 150 lb. It must be free from foreign material.

No. 1 Standard Breakable Scrap. Clean cast-iron scrap, such as columns, pipe, plates, and castings of miscellaneous nature, weighing over 150 lb., and which can be broken by an ordinary drop hammer into cupola size.

Cast-Iron Car Wheels. Cast-iron car and locomotive wheels. They are for use in the gray-iron foundry.

Brake Shoes. Driving and car brake shoes of all types, except composition-filled shoes. They are for use in gray-iron foundries.

Malleable Iron

No. 1 Malleable Scrap. Malleable parts of automobiles, railroad cars, and miscellaneous malleable castings. It must be free from steel and cast-iron parts. It is used in the gray-iron foundry.

No. 2 Malleable Scrap. Malleable parts of agricultural implements and other miscellaneous malleable castings. It must be free from steel and cast-iron parts, but may include carbon steel rail ends under 3 ft. long, of 50 lb. and over, in standard sections. This material is used in the gray-iron foundry.

Steel

Shoveling Turnings. Clean, short, steel and wrought-iron turnings, drillings, or screw cuttings free from stringy, bushy, or tangled material, corroded or rusty lumps, excessive oil, scale, other metals, dirt, or foreign material. Alloy steel scrap may be excluded by mutual agreement between buyer and seller. The material is used in the blast furnace.

Mixed Borings and Turnings. Clean, short, steel and wrought iron turnings, drillings, screw cuttings, and cast- or malleable-iron borings or drillings, free from stringy, bushy, tangled, corroded material, lumps, excessive oil, scale, other metals, dirt, or foreign material. Alloy steel scrap is excluded by mutual agreement between buyer and seller. It is used in the blast furnace.

Axle Turnings. Heavy short first-cut turnings from wrought-iron and steel railroad axles or heavy forgings, and rail chips, to weigh not less than 75 lb. per cubic foot, free from dirt or other foreign material of any kind. Alloy steel scrap may be excluded by mutual agreement. This material is used in the basic open-hearth furnace.

No. 1 Machine Shop Turnings. New, clean, steel or wrought-iron turnings, free from lumps, badly tangled

or matted material, cast-iron borings, other metals, excessive oil, dirt, or foreign material of any kind. Badly rusted or corroded stock is not acceptable. This material is used in the basic open-hearth furnace.

No. 2 Machine Shop Turnings. New, clean, steel or wrought-iron turnings, curly, bushy stock. It may contain tangled material, but must be free from badly rusted, lumpy or corroded stock. It should contain no cast-iron borings, other metals, excessive oil, dirt, or foreign material of any kind.

Corroded Borings and Turnings. Corroded and lump borings, turnings, and similar stocks free from scale, other metals, dirt, or foreign material of any kind. No dimensions will exceed 9 in. Alloy steel scrap may be excluded by mutual agreement between buyer and seller. It is used in the blast furnace.

No. 1 Heavy Melting Steel Scrap. Steel scrap ¼ in. and over in thickness, not over 18 in. in width and not over 5 ft. long. Individual pieces must be cut into shapes free from attachments and will lie flat in a charging box. Cut boiler plates must be practically clean and free from staybolts, and not over 3 ft. long. Smaller dimensions of plate scrap may be required by mutual agreement, but no piece is to weigh less than 5 lb. This material may include structural shapes, angle bars, plates, steel castings, heavy chains, carbon tool steel, heavy forgings, forged butts, and similar heavy material. It may also include mashed pipe ends, sheets, bars, billets, blooms, rail ends, railroad steel, and wrought scrap. No skeleton plate scrap, agricultural shapes, annealing pots, boiler tubes, grate bars, cast iron, malleable iron or unwieldy pieces are to be included. It must be free from dirt, excessive rust or scale, or foreign material of any kind. Alloy steel scrap may be excluded by mutual agreement.

No. 2 Melting Steel. Plate scrap, such as car sides, automobile frame stock, tank crops, ½ in. and heavier.

Steel parts of agricultural implements, automobile springs cut apart, rods and bars ½ in. and heavier. Punchings ¼ in. and over in thickness, heavy clippings, new unmashed pipe ends under 4 in. diam., horseshoes, and similar material. Car sides and all light plates are to be sheared 15×15 in. or under, and all tires and light rods are to be 12 in. or under in length. All twisted pieces must be sheared into such shapes that they will lie flat in the charging box. The material must be free from cast iron, malleable iron, scrap, dirt and foreign material of any kind. The maximum size is 15 in. wide by 3 ft. long, excepting car sides. Alloy steel scrap may be excluded by mutual agreement.

Heavy Shoveling Steel Scrap. Heavy, clean wrought-iron and steel scrap ¼ in., and over in thickness, not over 8 in. in breadth or length, and no piece less than the equivalent of ½ in. square, 3 in. long. It may include railroad spikes, bolts, nuts, tie plates, boiler, bridge and structural punchings and clippings, small bar and shafting crop ends, and other similar material. It must not contain burnt material, cast or malleable scrap, cut pipe and tank, skeleton stock, badly corroded material nor any twisted or tangled scrap. It must be free from foreign metals of all kinds, from galvanized, painted, enameled or other coated stock, and from dirt and rubbish. Alloy steel scrap may be excluded by mutual agreement between buyer and seller. This material is for use in the basic open-hearth furnace.

No. 1 Selected Shearing Scrap. Angles from 2 in. up to 8 in. Structural shapes in single members from 4 in. up to 9 in., bars ½ in. up to 4 in. in diameter, and flats ½ in. to 2 in. thick and from 1 to 10 in. wide. It is to be straight lengths and free from dirt and foreign material of any kind. Long length girder rails, free from cast welds and attachments, may be included by mutual agreement.

Hydraulically Compressed Sheet Scrap. New, black steel sheet clippings, shearings, skeleton stamping scrap, side and end sheet, and tin-mill scrap, hydraulically

compressed into compact, rectangular packages not to exceed 20 in. longest dimension, weighing not less than 75 lb. per cu. ft. It must be clean and free from excessive rust, paint, or protective coating of any kind. No de-tinned scrap, electrical sheet, or material over 0.50 per cent silicon will be accepted.

SHORT SHOVELING FLASHINGS. Flashings or trimmings from iron or steel forgings, to be 10 in., or under, in length, suitable for hand shoveling, and to include no tangled or twisted material. Alloy steel stock may be excluded by mutual agreement. The material is used in the basic open-hearth furnace.

LONG FLASHINGS. Flashings or trimmings from iron or steel forgings which have been separated to a minimum length of 20 in. and not exceeding a maximum of 36 in. There must be a thickness in some sections of each of these flashings of not less than 3/16 in. Alloy steel stock may be excluded by mutual agreement. The material is used in the basic open-hearth furnace.

MIXED FLASHINGS. Flashings or trimmings from iron and steel forgings not over 36 in. in length. Alloy steel scrap may be excluded by mutual agreement. The material is used in the basic open-hearth furnace.

NO. 1 BUSHELING. Clean iron and soft-steel pipe and flues, tank, cut hoops and bands of No. 12 gage or heavier, steel plate punchings and clippings, soft steel and iron forgings, and flashings. No dimension should be over 8 in. It is to be free from burnt material, hard steel, cast, malleable, and galvanized or metal-coated material of any kind. It is for use in the basic open-hearth furnace.

NO. 2 BUSHELING. Cut hoops, netting, sheet, and similar material lighter than No. 12 gage. No dimension is to be over 8 in. It must be free from hard steel, cast, malleable, and galvanized or metal-coated material. It is for use in the basic open-hearth furnace.

No. 1 Selected Rail Scrap. Standard sections, T and guard rails, 40 lb. and heavier per yard, and less than 36 in. long. It must be free from frog and switch rails not cut apart, and to contain no manganese-steel scrap or cast welds or attachments of any kind.

Baled Sheet Scrap. New, black sheet-steel clippings, shearings, skeleton stamping scrap, side and end sheet and tin-mill scrap, machine baled into angular packages, tied with wire or bands, or sufficiently compact not to come apart in handling with a magnet. Not over 24 in. longest dimensions, and weighing not less than 45 lb. per cu. ft. It must be clean and free from excessive rust, paint, or protective coating, and from de-tinned scrap, electrical sheets, or material over 0.50 per cent silicon.

Hand Bundled Sheet Scrap. New, black steel clippings, shearings, skeleton stamping scrap, side and end sheet and tin-mill scrap, securely tied with not less than two wires or bands, in packages not over 18×18 in. by 3 ft., weighing not over 125 lb. It should be bundled so that the packages will not come apart in handling with a magnet. It must be clean and free from excessive rust, paint, or protective coating of any kind. No de-tinned stock, electrical sheet nor material over 0.50 per cent silicon is acceptable.

Loose Sheet Clippings. New, black sheet-steel clippings, shearings and stampings 3/16 in. and lighter, free from exessive rust, paint, or protective coating of any kind. It should be not over 18 in. wide or long, or if edge trimmings or shearings it should be not over 12 in. × 5 ft. long. No de-tinned scrap, electrical sheet nor material over 0.50 per cent silicon is acceptable.

Galvanized or Coated Sheet Scrap. New, clean sheet-steel scrap, composed in whole or in part of material having a coating of zinc, paint, or protective material. It must be specified as galvanized or coated scrap and classified according to the manner in which it is prepared

for shipment. No material over 0.50 per cent silicon is acceptable.

De-Tinned Sheet Scrap. Sheet-steel clippings or shearings originally covered with a protective coating of tin or lead and tin, but from which such foreign metals have been removed. Must be clean, contain no material over 0.50 per cent silicon, and be free from badly rusted or corroded stock.

Electrical Sheet Scrap. New, clean sheet-steel scrap, composed in whole or in part of materials from 0.50 per cent to 1 per cent silicon. Must be clearly specified as electrical sheet scrap. It is for use in the basic open-hearth furnace.

High-Silicon Sheet Scrap. New, clean, sheet-steel scrap composed in whole or in part of material over 1 per cent silicon.

Car Wheels. Solid cast-steel, forged, pressed or rolled steel car and locomotive wheels not over 36 in. in diameter. This material is for use in the acid open-hearth furnace.

Spring-Steel Scrap. Coil and elliptical steel springs made of material not less than $\frac{3}{8}$ in. diameter, or $\frac{1}{4}$ in. thick. It must not be over 18 in. wide, and must be sheared to lengths not over 48 in. It may be assembled or cut apart.

Nickel-Steel Turnings. Heavy, short, first-cut turnings from nickel-steel forgings. Nickel and chromium contents are to be specified on each individual sale. It must weigh not less than 75 lb. per cu. ft., and be free from dirt and other foreign materials. It is for use in the acid open-hearth furnace.

Guaranteed Heavy Scrap. Open-hearth steel plates, structural shapes, crop ends, shearings, broken steel tires, tool steel, and spring steel. It should be not less than $\frac{1}{4}$ in. thick, other dimensions subject to agreement. It must be not over 0.04 per cent in phosphorus or sulphur, clean,

free from excessive rust, and contain no foreign material. It is for use in the electric furnace.

Unguaranteed Scrap. Steel plate, shearings, nut and bolt punchings, short rails and other similar material, not less than ¼ in. in thickness and not over 12 in. in width or length. It is not guaranteed under 0.04 per cent phosphorus or sulphur. It must be suitable for hand charging, and must be free from galvanized and coated stock, foreign material, and excessive rust. It is for use in the electric furnace.

Guaranteed Axle Turnings. Heavy, steel or iron axle or forge turnings, guaranteed not over 0.04 per cent in phosphorus or sulphur. It must contain no foreign material and must be clean and free from excessive rust. It should weigh not less than 75 lb. per cu. ft. It is for use in the electric furnace.

Unguaranteed Turnings. Short, heavy shoveling steel or wrought-iron turnings, not guaranteed under 0.04 per cent in phosphorus or sulphur. It should contain no foreign material, and must be free from excessive rust. It should weigh not less than 75 lb. per cu. ft. It is for use in the electric furnace.

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